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Equilibrium Beach Profile
Measurement and Sediment Analysis:
Mustang Island, Texas

Major Report

by

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Abstract

This engineering report describes the measurement techniques and results of an equilibrium beach profile survey and sediment analysis conducted by Texas A&M University, Ocean Engineering Program, at Mustang Island, Texas on September 27, 1997. The main objective of the project was to obtain an accurate equilibrium beach profile at a location on Mustang Island, and to compare the actual profile to a predicted profile. The predicted profile is based on the median grain size diameter of sediment samples taken from the dune crest to approximately 4000 ft offshore.

The survey was accomplished using an electronic total station with a standard surveying rod on land, and the underwater profile was measured with a "sled" towed behind a boat. A triple prism was attached to both the top of the rod and sled. The sled is an aluminum and steel structure equipped with two 12 ft long skids and a 36.5 ft mast.

The predicted profiles are based on two methods. One method uses Dean's (1997) equation for equilibrium beach profiles, $z = Ax^{2/3}$, where z is the water depth, A is the profile scale factor related to the sediment fall velocity, and x is the distance offshore. The other method involves a more complex analysis described by Dean and Dalrymple (1996), which accounts for a variation in sediment size and profile scale factor, A, in the offshore direction. Both methods are described and compared in this report. This data will also be used by Dr. R. G. Dean of the University of Florida in a study he is conducting on equilibrium beach profile prediction.

Dedication

This report is dedicated to Jill, Amber, and Sammi for all of their love, patience, and assistance.

Acknowledgments

I would like to thank my committee members, Dr. Billy L. Edge, Dr. Robert E. Randall, and Dr. Robert O. Reid. Their guidance through this project is greatly appreciated. Special thanks to Dr. Daniel T. Cox, and Dr. Kelly L. Rankin for their assistance and technical support both in and out of the field. Thanks are also expressed to Dr. James S. Bonner and James Risso for their boat, supplies, and experience, and to Dr. Robert F. Bruner for the surveying equipment. Finally, I would like to thank John Reed, Michael Schrepfner, and my working crew: Steven Howard, Bill Hobensack, Ben Cole, Monty Conner, and Sean Kelley.

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Introduction

Project Mission

The main objective of this project was to obtain an accurate equilibrium beach profile at a location on Mustang Island, and to compare the actual profile to a predicted profile. The location of Mustang Island can be seen in Figure 1. The predicted profile is based on the median grain size diameter of sediment samples taken at the location from the dunes to approximately 4000 ft offshore. This project will use relationships described by Dean and Dalrymple (1996) in the analysis of the sediment grain sizes and predicted beach profiles.

There are two relationships for predicting equilibrium beach profiles which will be compared in this report. One relationship involves predicting the beach profile based on one sediment grain size obtained from the mid-shore or foreshore region of the beach. The other relationship accounts for variations in sediment grain size in the offshore direction. The later relationship is more realistic because it accounts for the natural hydrodynamic sorting of sand sizes, where sand sizes become finer in the offshore direction (Dean & Dalrymple, 1996).

This project involved two days of field work on Mustang Island, Texas. The data collection was two-fold. A survey crew collected all data pertaining to the beach profile. A dive crew collected sediment samples in the offshore direction up to a depth of about 35 ft. The data collection techniques and results from both crews are described in detail in this report.

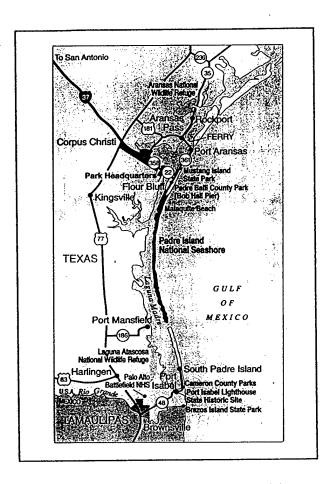


Figure 1. Location of Mustang Island State Park in relation to Corpus Christi, Texas.

This data will also be used by Dr. Robert G. Dean of the University of Florida in a "blindfolded" study he is conducting on equilibrium beach profile prediction. The results of the sediment analysis and location of samples will be sent to Dr. Dean. Dr. Dean will then calculate and plot a predicted equilibrium profile based on the sediment grain size from a FORTRAN program he is writing. A copy of this predicted profile will be returned, and the measured profile will then be sent to Dr. Dean.

Equilibrium Beach Profiles

A beach profile is the variation in the vertical change of the sea floor with the distance offshore, and it is measured perpendicular to shore. A beach profile is synonymous to a topographical map for the sea. The concept of an equilibrium beach profile came about in 1977 with the research of Dr. Robert Dean of the University of Florida. Dean examined over 500 beaches from the Atlantic and Gulf coasts and developed a relationship describing the water depth as being proportional to the distance offshore to the two-thirds power for a given sediment grain size.

The predicted profiles are based on two methods. One method is simply using Dean's (1977) equation for equilibrium beach profiles, $z = Ax^{2/3}$, where z is the water depth, A is the profile scale factor related to the sediment fall velocity, and x is the distance offshore. The other method involves a more complex analysis described by Dean and Dalrymple (1996), which accounts for a variation in sediment size and profile scale factor, A, in the offshore direction. This method is more realistic because it accounts for the natural sorting of sand sizes from coarser to finer diameters in the cross-shore direction. Both methods are described and compared in this report.

The survey of the beach profile was divided up into two sections: land and sea.

The land profile was measured using an electronic total station and a standard surveying rod with a triple prism attached. The underwater profile was measured with a "sled" towed behind a boat. A triple prism was also attached to the top of the sled. The sled was originally designed and built by Rudolph Pesek, an undergraduate student at Texas

A & M, as his senior design project. The sled is an aluminum and steel structure equipped with two 12 ft long skids and a 36.5 ft mast.

Before this project, the sled had only been tested in a trial run at Lake Bryan near Bryan, Texas. The test consisted of setting up the sled and successfully towing it into the lake and back. There was no need for survey equipment because the goal of the test was to observe the sled's ability to be towed. It was found that the sled behaves well in tow, but it requires a boat with more that 150 hp to be towed successfully.

Sediment Grain Size

Sediment grain size varies across a beach in the cross-shore direction. Sediment median grain sizes become smaller with a decrease in wave intensity. This decrease in sediment grain size also correlates with a decrease in beach face slope (Bascom, 1951). It has also been shown that the decrease in beach face slope with smaller diameter grain sizes also continues in the offshore direction.

Sediment samples were taken along the beach profile in the cross-shore direction from the dunes to about 4000 ft offshore. A sieve analysis was conducted on these samples and the grain size distribution was determined for each sample. The samples taken in the cross-shore direction will show the variation in sediment size. The beach slope variation will also be compared to the distance offshore, and the beach slope will also be correlated to the median sediment diameter, d_{50} .

Background Theory

Surveying Techniques for Equilibrium Beach Profiles

Beach profile measurement techniques usually involve an amphibious operation where the surveyor must survey on land and at sea. Typically, a land survey is completed using land surveying techniques. That data is combined with an offshore survey which measures the underwater beach profile. Figure 2 illustrates these amphibious surveying techniques. Although land surveying techniques are common, surveying an underwater beach profile is still a challenging and developing field.

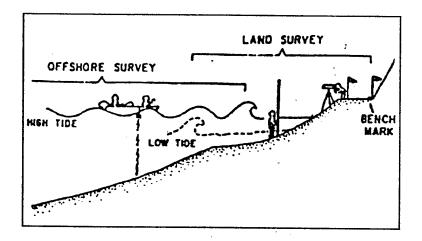


Figure 2. Beach Profile Survey Technique (Dean & Dalrymple, 1996, from Nordstrom and Inman, 1975)

Offshore profiles can be completed using a number of methods. The most common method is obtained by using a survey boat equipped with a positioning system such as LORAN-C or Global Positioning System (GPS), and a fathometer. The boats

position is later correlated with the depth measurements to give the beach profile. A correction to this profile must be applied for all tidal bodies of water which accounts for the tidal water level. The effect of waves are generally accounted for by "smoothing out" the profile and using only the average depth values. The disadvantage to this method is that true irregularities of the beach profile may be lost using this method (Dean & Dalrymple, 1996).

Another method for obtaining offshore beach profiles is the use of vehicles like the Coastal Research Amphibious Buggy (CRAB) of the U.S. Army Corps of Engineers Coastal Research Center shown in Figure 3. The CRAB is a massive 35 ft high, 29.5 ft long tripod equipped with a Volkswagen industrial gasoline engine which drives an Eaton hydraulic pump. The hydraulic pump powers the three liquid filled tires which are over 5 ft in diameter. The CRAB is equipped with a prism cluster, and uses a land based Zeiss Elta-2 electronic total station to obtain profile data (Birkemeier & Mason, 1984).

The CRAB can operate in rough seas and it also eliminates the need for tide measurements. It is also equipped with various scientific instruments which measure wave height, current velocities, and it can take core samples. Despite the obvious advantages of the CRAB, it also has a few astounding disadvantages. The most obvious is the CRAB's lack of portability. The CRAB's operational weight is 18,000 lbs and minimum transport weight is 15,000 lbs. It is usually transported by a CH-5 Chinook helicopter, but it meets the helicopter's maximum payload capacity of 15,000 lbs. The

other obvious drawback is the CRAB's high initial cost (Birkemeier & Mason, 1984).

The CRAB would definitely be a welcome addition to any coastal engineering program, however, very few research institutions or universities can afford the high initial cost or maintenance for such a vehicle. Therefore, there must be a cheaper alternative for obtaining equilibrium beach profiles offshore.

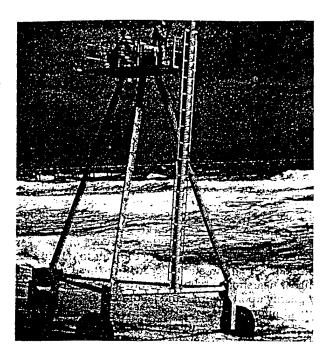


Figure 3. Coastal Research Amphibious Buggy (Birkemeier & Mason, 1984)

One alternative to using a boat with a fathometer, or a CRAB like vehicle is the use of an amphibious sea sled which can be towed offshore by boat from the dry beach.

This method of obtaining equilibrium beach profiles was used in this research project.

A general definition of a sled is a structure which slides across the sea floor on skids and supports a surveying prism or other positioning device such as a GPS antenna. The sled

used in this project is an aluminum and steel structure equipped with a 36.5 ft mast, two 12 ft long skids, and supports a triple prism atop the mast. Figure 4 shows the basic dimensions of the Texas A & M University sled, and Figure 5 shows the height of the structure. Advantages of the sled are low initial and maintenance costs, ease of portability and operation, and accuracy of results. The major disadvantage is the need for a boat to tow the sled offshore.

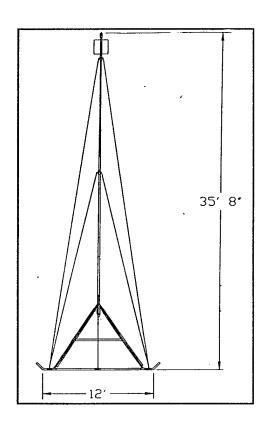


Figure 4. Diagram of basic sled dimensions.

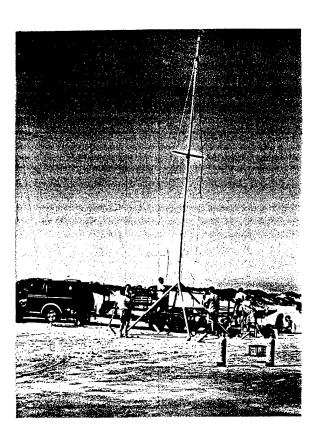


Figure 5. Sled towering over survey site.

Equilibrium Beach Profile Prediction

The development of an equilibrium beach profile theory has been a major advance in the field of beach nourishment design. It has given coastal engineers the ability to predict the equilibrium shape of beach nourishment projects. Equilibrium beach profile theory also assists in calculating the amount of sediment that will be needed to nourish these beaches.

The concept of an equilibrium beach profile was first identified by Bruun in 1954. In field studies of beach profiles off the coasts of California and Denmark, Bruun noticed that the beach profiles were well represented by a two-thirds power curve. Dean (1977) further examined this concept in a study of 502 beach profiles from the east coast of the United States and Gulf of Mexico. Dean found that each profile followed the generalized power law of $z = Ax^{2/3}$, where z is the depth of the profile below the mean water level, A is a profile scale factor, and x is the distance offshore. Dean also found that this two-thirds power law relationship agreed remarkably well with a relationship derived from examining the destructive forces on a beach (Dean & Dalrymple, 1996).

The equilibrium beach profile theory developed by Dean is based on the assumption that the dominant destructive force acting on a beach is turbulence caused by breaking waves. The development of the theory is based on the concept that a sediment of a given grain size is able to withstand a given level of wave energy dissipation per unit volume. The first step in deriving an equation for the equilibrium beach profile is to develop an equation for the conservation of energy in the surf zone.

This is done by setting the change in wave energy flux over a certain distance equal to the water depth multiplied times the uniform energy dissipation rate per unit volume for a given grain size (Dean & Dalrymple, 1996). This relationship is show in equation 1.

$$\frac{dF}{dx} = zD \tag{Eq. 1}$$

The wave energy flux is given by the following equation:

$$F = \frac{1}{8} \rho g H^2 \sqrt{gz}$$
 (Eq. 2)

where ρ is the density of sea water, g is the acceleration due to gravity, k is a constant for the wave breaking index, and z is water depth (Dean & Dalrymple, 1996).

The next step is to take the derivative of the wave energy flux and simplify the energy dissipation rate per unit volume from equation 1 to get equation 3 (Dean & Dalrymple, 1996).

$$D = \frac{5}{16} \rho g^{3/2} k^2 z^{1/2} \frac{dz}{dx}$$
 (Eq. 3)

Finally, the equation representing the equilibrium beach profile is calculated by integrating the water depth, z, with respect to the distance offshore, x. Equation 4 is the result of this derivation for an equilibrium beach profile equation (Dean & Dalrymple, 1996).

$$z(x) = \left(\frac{24D}{5\rho g\sqrt{g}k^2}\right)^{2/3} x^{2/3} = Ax^{2/3}$$
 (Eq. 4)

where A is defined as the profile scale factor which is a function of the energy dissipation and the grain size of the beach. As mentioned before, this equation for representing an equilibrium beach profile derived from the dominant destructive forces acting on a beach agrees remarkably well with the empirical relationship described by both Bruun(1954) and Dean (1977).

There are many methods for predicting equilibrium beach profiles. Two of these methods are discussed and applied in this report. The first relationship involves predicting the beach profile based on one sediment grain size obtained from the midshore region of the beach. The second relationship accounts for variations in sediment grain size in the offshore direction. The first method will be referred to as method 1, and the second method as method 2. The later relationship is more realistic because it accounts for the natural hydrodynamic sorting of sand sizes, where sand sizes become finer in the offshore direction (Dean & Dalrymple, 1996).

The first method in determining the equilibrium beach profile is the simpler of the two. According to Dalrymple and Dean (1996), for an equilibrium beach profile, the depth is proportional to the profile scale factor, "A", multiplied by the distance offshore to the two-thirds power. Dean (1977) described the relationship for the equilibrium beach profile using the following equation which was derived earlier as equation 4 (Dalrymple & Dean 1996):

 $z = Ax^{2/3}$ (Eq. 5)

where z is the water depth (m), A is the profile scale factor ($m^{1/3}$) related to the sediment fall velocity, and x is the distance offshore (m).

The profile scale factor, "A", was related to the sand diameter, d, by Moore (1982). Dean (1987) further related the profile scale factor, "A", directly to the fall velocity (m/s), w, in the equation (Dalrymple & Dean, 1996):

$$A = 0.067 w^{0.44}$$
 (Eq. 6)

The fall velocity (cm/s), w, was related to the median sediment diameter (mm), d_{50} , by Hallermeier (1981) with the equation (Edge, 1997):

$$w = 14d_{50}^{1.1} (Eq.7)$$

The relationships between the sediment fall velocity, w, sediment size, d, and profile scale factor, A, can be seen in Figure 6.

As mentioned before, method 1 for predicting equilibrium beach profiles does not take into account the cross-shore variation in sediment grain size. However, the sediment grain size does vary in the cross-shore direction, and the slope of the beach also varies with the change in sediment diameter. For this reason, Dean and Dalrymple (1996) describe an alternate method for predicting equilibrium beach profiles which takes into account the variation in sediment grain size diameter. This method is referred to as method 2.

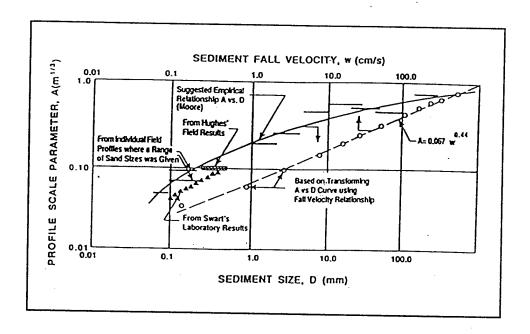


Figure 6. Profile Scale Factor, A versus Sediment Diameter, d, and Fall Velocity, w (Dean, 1987; adapted in part from Moore, 1982)

Method 2 assumes that the profile scale factor, A, varies linearly between two adjacent locations. Dean and Charles (1994) developed a relationship for this variation in profile scale factor between two known samples. This relationship is described in the equation (Dean & Dalrymple, 1996):

$$A(x) = A_n + \frac{A_{n+1} - A_n}{x_{n+1} - x_n} (x - x_n)$$
 (Eq. 8)

for $x_n < x < x_{n+1}$. So, between any two sample locations where the profile scale factor, A, is known, an estimated profile scale factor can be calculated.

Furthermore, if a profile scale factor is also known between two points, then the beach profile between those two points is expressed by the equation (Dean &

Dalrymple, 1996):

$$z(x) = (z_n^{3/2} + A_n^{3/2} (x - x_n))^{2/3}$$
 (Eq. 9)

for $x_n < x < x_n$.

With these relationships, the equilibrium beach profile can be calculated across a beach where the sediment grain size varies in the cross-shore direction.

Sediment Grain Size Analysis

In order to determine the profile scale factor, A, the median sediment grain size, d_{50} , is needed. One method of determining the median grain size along with many other sediment size distribution parameters is to sort the sediment into its various size components based on the sediment diameter by the use of sieves. The methods for sieving sediment samples will be discussed in detail later in this report. This section, however, will describe other sediment distribution parameters not already mentioned above which are commonly used to describe sediment samples.

Other sediment size distribution parameters such as the standard deviation and skewness of the sediment sample are useful in describing certain characteristics about a sediment sample. These calculations are based in the phi unit scale proposed by Krumbein (1936). The phi unit is defined in equation 10 below (Shore Protection Manual, 1984):

$$\Phi = -\log_2(d)$$
(Eq. 10)

where ϕ is the sediment size in phi units, and d is the sediment grain diameter in millimeters.

The standard deviation of the sample is used to determine how well a sample is sorted around the mean grain size. Inman (1952) defined the standard deviation to be (Shore Protection Manual, 1984):

$$\sigma = \frac{\Phi_{84} - \Phi_{16}}{2}$$
 (Eq. 11)

where σ is the standard deviation of the sample, ϕ_{84} is the grain size that is coarser than 84 percent of the sample by weight, and ϕ_{16} is the grain size that is coarser than 16 percent of the sample by weight. The values of ϕ_{16} , ϕ_{84} , and ϕ_{50} , are typically obtained from a cumulative percent coarser plot as seen in the example size distribution of Figure 7.

A standard deviation equal to zero represents a perfectly sorted sample, and for a well-sorted sample the standard deviation is around 0.5. A well-sorted sample is poorly-graded meaning that its particles are close to a typical size. Conversely, a well-graded sample is poorly-sorted.

The skewness of the sample indicates how well the sediment sizes are distributed about the mean size of the sample. The skewness was defined by Inman (1952) to be (Shore Protection Manual 1984):

$$\alpha = \frac{M_{\phi} - M_{d\phi}}{\sigma_{\phi}}$$
 (Eq. 12)

where a is the skewness of the sample, M_{ϕ} is the mean phi size as calculated below with equation 9, $M_{d\phi}$ is the median phi size obtained from the value of d_{50} on the percent coarser plot, and σ_{ϕ} is the standard deviation in phi units.

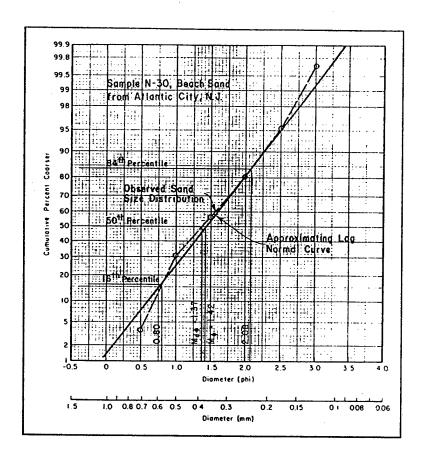


Figure 7. Example size distribution (Shore protection Manual, 1984)

The mean phi size, M_{ϕ} , was defined by Otto (1939) and Inman (1952) to be (Dalrymple & Dean 1996):

$$M_{\phi} = \frac{\Phi_{84} + \Phi_{16}}{2}$$
 (Eq. 13)

A sample that has a perfectly symmetric distribution about the mean has a skewness of zero. A negative skewness indicates that the sample is skewed towards the smaller phi sizes, or larger grain sizes. According to Dalrymple and Dean (1996), Duane (1964) showed that a negative skewness indicates an erosive environment where the finer materials have been removed from waves or currents. On the contrary, a positive skewness indicates a depositional environment.

Methodology

Equilibrium Beach Profiles

The equilibrium beach profiles measured in this project were completed by matching the results of a land survey with an offshore survey. Two separate profiles were measured, and they were labeled profiles A & B. Profile A was located about three miles northwest of the "Fish Pass" jetties on Mustang Island. The jetties are located just north of Mustang Island State Park and south of the first beach access road after the park. Figure 8 shows the location of the "Fish Pass" jetties and approximate location of profile A. For profile A, sediment samples were taken along the profile. Profile B was completed about 300 ft south of profile A, and its main purpose was to verify the results of profile A.

The land survey was completed with the use of an electronic total station and a standard surveying rod with a triple prism cluster attached to the top. At the time of the survey, there was no known benchmark data or geographical datum to reference the beach surveys. Therefore, a 5 ft long, 1 inch diameter steel pipe was hammered into the dune as a permanent marker for the survey and assumed to be origin of the survey. Range poles were also set up to keep the rod man and sled aligned with the profile. The rod was then walked out from the dunes in the offshore direction until the rod man could not stand up in the water without swimming. Meanwhile, the electronic total station delivered horizontal distance measurements, and horizontal and vertical angles. Figure 9 shows the survey crew operating the electronic total station. The readings were later

converted into X, Y, and Z coordinates of position. This method was used to compile a land survey for both profile A & B.

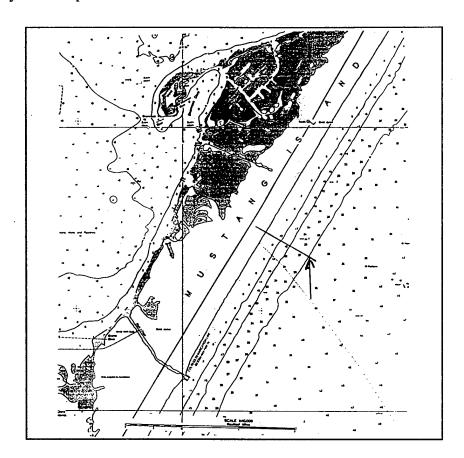


Figure 8. Approximate location of beach survey on Mustang Island.

The offshore survey involving the sled began in the surf zone where the sled was towed offshore by boat. The sled is a 400 lb aluminum and steel structure equipped with a 36.5 ft mast, two 12 ft long skids, and supports a triple prism atop the mast. It requires a relatively powerful tow boat with a shallow draft which allows it to come close to shore in shallow water. The boat used to tow the sled in this project was

charted out of Port Aransas, Texas. The boat was a 25 ft twin hulled Seacat equipped with two 150 hp engines. Its draft was about 1.5 ft which allowed it to come relatively close to shore. The attachment of tow lines and movement of equipment and personnel from the beach to the tow boat was completed with the use of a Zodiac boat.



Figure 9. Survey crew operating electronic total station.

Once the sled was ready, the first offshore profile, profile A, began. The tow boat pulled the sled offshore until it reached a depth of about 35 ft. Figure 10 shows the sled beginning a survey in the surf zone. Along the way, the boat stopped at designated locations so a diver could collect sediment samples. The locations of the sediment samples were set to be at about every one meter of depth change. To aid in identifying

every one meter depth change, orange marks were painted on the sled mast at one meter intervals. Once the sled reached a depth of 35 ft, the boat towed the sled to the next profile location approximately 300 ft south. The sled was then towed from offshore toward the beach for profile B.

The assembly of the sled involves at least four people and takes about five hours.

The details of the assembly are not discussed in detail in this report. However,

Appendix C contains all the pertinent diagrams and assembly instructions to the sled.

Appendix A also contains a check list of materials and list of contacts.



Figure 10. Sled entering surf zone.

Sediment Collection

Sediment samples were taken along the beach profile at 13 different locations.

The method of obtaining the sediment samples involved a SCUBA diver equipped with a tin coffee can for gathering the sample. The diver "rode" the sled underwater from the beach to a distance of about 4000 ft offshore. At designated locations, the diver scooped up about 1 kilogram of sediment into the coffee can. These sample locations are illustrated in Figure 11. The diver then surfaced to give the sample to an awaiting Zodiac boat. In the boat, the sample was transferred to a plastic bag where it was labeled.

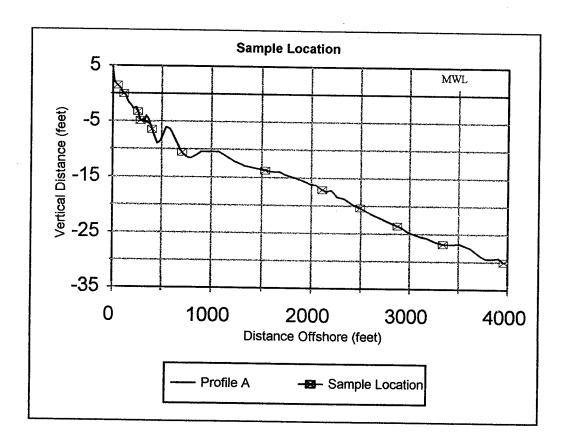


Figure 11. Sample Location.

The method of "riding" the sled was not the original plan for sediment collection. The original plan involved the Zodiac boat being the launch platform for the diver. The diver would ride in the Zodiac between dives, and then dive at each location from the surface. This method would have required the diver to make 10 surface dives and to pull his equipment out of the water and into the Zodiac the same number of times in about an hour and a half period. After two attempts at this method, it proved to be too strenuous for the diver. Therefore, the diver submerged after delivering each sample to the Zodiac and held onto the sled underwater while it was towed by the boat. This proved to be less strenuous on the diver, and also provided a bird's eye view of the sled's behavior underwater. The diver observed that the sled's bow is lifted while in tow and because of this the sled does not "dig" into the sea floor. Figure 12 shows the diver in action.

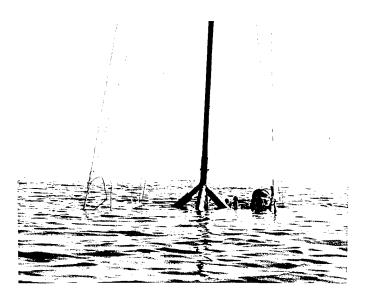


Figure 12. Diver, Erick Knezek, preparing to collect sediment samples

Sieve Analysis

The sediment analysis was completed using U.S. standard sieves. A sieve analysis involves sorting the sediment sample in sieves stacked in order from largest to smallest openings. First, each sample was placed in an oven and baked at 500° F for 30 minutes to remove all moisture. Next, the sieves were stacked in order of decreasing opening size (largest opening on top). Sieve numbers 60, 80, 100, 120, 140, 170, 200, and a collection pan were used to sort the sediment. These sieve numbers correspond to the number of mesh openings per inch of area on the sieve. The corresponding phi units for these sieves were 2.00, 2.47, 2.74, 3.00, 3.24, 3.47, and 3.74.

The Shore Protection Manual (1984) states that standard sieve openings vary by 0.25 phi increments, but recommends that beach sand can be adequately analyzed using 0.5 phi increments. The sieve openings in this analysis vary by about 0.25 phi increments which gives a more definitive sediment distribution. The relationship between the sieve mesh size, and corresponding sediment diameters in phi units and millimeters can be seen in Figure 13.

Each sample was weighed using an electronic scale before and after each sorting. Once each sample was dried and weighed, a 400 gram sample was placed in the number 60 sieve. The sieve stack was then placed on an electric shaker on high speed for ten minutes to sort each sample. After sorting, the sediment remaining in each sieve was weighed individually to determine the grams retained. From this data, the cumulative percent coarser for each sieve diameter was determined and plotted. From the plot, the

values of ϕ_{16} , ϕ_{84} , and ϕ_{50} , were obtained.

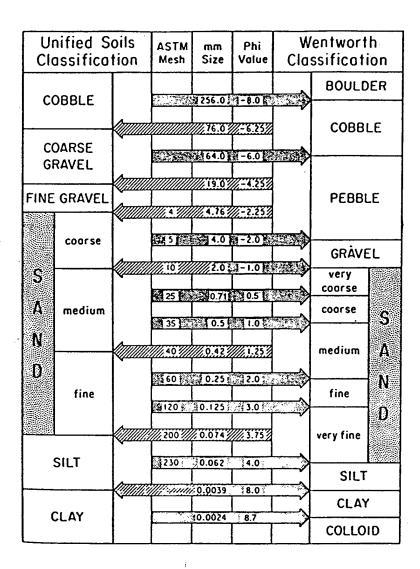


Figure 13. Grain-size scales for soil classification (Shore Protection Manual, 1984)

Discussion of Results

Equilibrium Beach Profile

The equilibrium beach profiles measured in this project seem to be very accurate representations of the sea floor variation on Mustang Island at the time of the survey. In Figure 14, the measured profiles A and B are compared. Although profile B was measured about 300 ft south of profile A, there is remarkable resemblance between the two profiles. There are no obvious differences between the two profiles, therefore it can be assumed that profile A is representative of the beach profile at the survey site.

Profile A will be used throughout the remainder of this report for the analysis of sediments, beach slopes, and profile prediction methods.

In order to obtain both beach profiles, the data given by the electronic total station had to be converted from horizontal distance measurements, and horizontal and vertical angles into X, Y, and Z coordinates of position. This was accomplished through the use of a spreadsheet program. A copy of the spreadsheet for profile A and B can be found in appendices B-1 and B-2, respectively. The conversion from distance and angle measurements to X, Y, Z coordinates was completed using basic trigonometric functions. The following relationships were used in those calculations:

$$X_{coordinate} = X_{initial} - H[\cos(\theta_{horizontal})]$$
 (Eq. 14)

where $X_{initial}$ is an initial X value such as distance from benchmark, H is the horizontal distance measurement given by the electronic total station, and $\theta_{initial}$ is the horizontal

angle given by the total station.

$$Y_{coordinate} = Y_{initial} - H[\sin(\theta_{horizontal})]$$
 (Eq. 15)

where Y_{initial} is an initial Y value, and H and $\theta_{\text{horizontal}}$ are as defined above.

$$Z_{coordinate} = Z_{initial} + HI + H[\sin(\theta_{vertical})] - RH$$
 (Eq. 16)

where Z_{initial} is an initial Z value, HI is the height of the electronic total station, RH is the height of the survey rod or sled, and θ_{vertical} is the vertical angle measurement given by the total station.

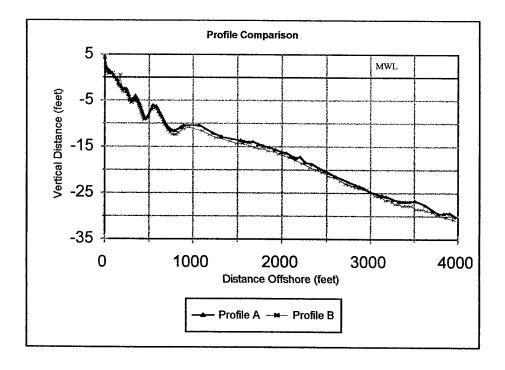


Figure 14. Measured beach profile comparison.

The matching of the land survey and offshore survey was also successful. There are no discontinuities or discrepancies between the survey conducted with the rod and the survey conducted with the sled. Both methods also seem to be very proficient at measuring irregularities in the bottom contour. Three or four distinct bars are apparent on the plot of the beach profiles in Figure 14.

There were a few sources of error in the measurement and analysis of the beach profiles. The location of the mean water line was not accurately measured in the field. All predicted profiles begin at the location of the mean water line, so an estimated mean water line was established. This was done by estimating the width of the beach from photographs, and also from notes taken by the data recorder on the location of the maximum wave runup.

Another source of error in the measurement of the actual beach profile was caused by the boat captains inability to keep the sled on the profile track. Figure 15 shows the actual sled's track along the profile lines. As seen in the figure, the sled was usually within 100 ft or 2.5 percent of the profile length off the profile line. The sled began profile B offshore at the maximum distance of 200 ft or 5 percent of the profile length off the profile line. Overall, the boat captain did maintain the sled position along the profile line reasonably well.

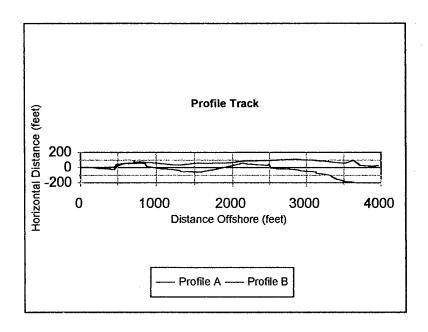


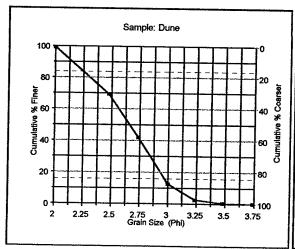
Figure 15. Actual sled track along profile line

Sediment Grain Size Analysis

The analysis of the sediment samples from profile A show the expected trend of the median grain sizes decreasing in the offshore direction. Once the sediments were sieved, the results were input into a spreadsheet program like the one seen in Table 1. With the values for number of grams retained in each sieve, the cumulative percent coarser plot for each sample was created. Figures 16-28 show the sediment distribution plots for each sample. From these plots, the values of ϕ_{16} , ϕ_{84} , and ϕ_{50} , were obtained, and the appropriate sediment characteristics were calculated. Appendix B-4 through B-6 contain the remainder of the calculations.

Table 1. Sample of sediment analysis technique.

Sample sieve #	Dune d (mm)	Phi	retained (gms)	% retained partial	total	% finer	% coarser
60	0.250	2.00	3.09	0.9	0.9	99.1	0.9
80	0.180	2.47	103.08	29.9	30.8	69.2	30.8
100	0.150	2.74	94.3	27.3	58.1	41.9	58.1
120	0.125	3.00	101.75	29.5	87.6	12.4	87.6
140	0.106	3.24	34.49	10.0	97.6	2.4	97.6
170	0.090	3.47	7.23	2.1	99.7	0.3	99.7
200	0.075	3.74	1.06	0.3	100.0	0.0	100.0
		Total	345.0				
Phi 16 =	2.24			Std Dev =	0.37		
Phi 50 =	2.65		;	Skew =	-0.08		
Phi 84 =	2.97			Vf (cm/s)=	1.86		
d50 (mm)=	0.159			A (m^1/3)=	0.09		
M phi =	2.62		•	Vf (ft/s) =	0.061		
dM (mm)=	0.163			4 (ft^1/3) =	0.131		



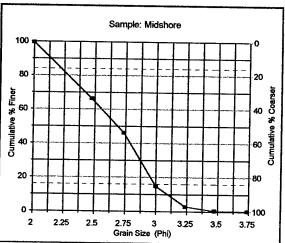


Figure 16. Sediment Distribution: Sample Dune

Figure 17. Sediment Distribution: Sample Midshore

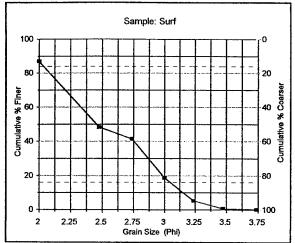
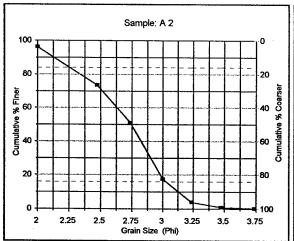


Figure 18. Sediment Distribution: Sample Surf Zone

Figure 19. Sediment Distribution: Sample A-1



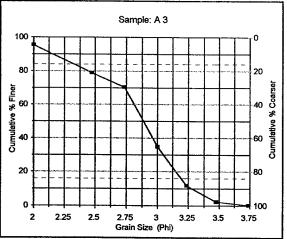


Figure 20. Sediment Distribution: Sample A-2

Figure 21. Sediment Distribution: Sample A-3

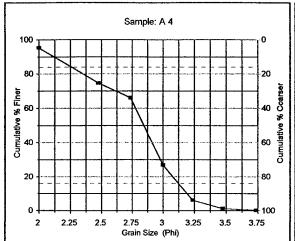
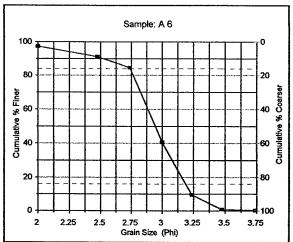


Figure 22. Sediment Distribution: Sample A-4

Figure 23. Sediment Distribution: Sample A-5



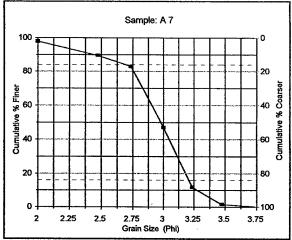


Figure 24. Sediment Distribution: Sample A-6

Figure 25. Sediment Distribution: Sample A-7

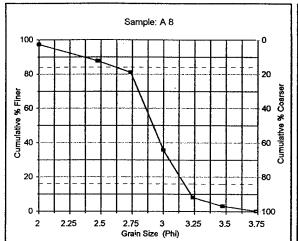


Figure 26. Sediment Distribution: Sample A-8

Figure 27. Sediment Distribution: Sample A-9

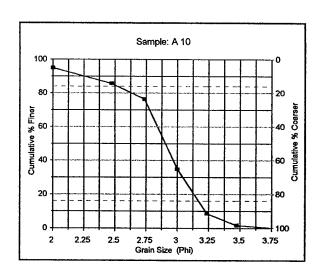


Figure 28. Sediment Distribution: Sample A-10

Table 2 summarizes the results of the sediment grain size analysis. The sediment diameters follow an obvious trend of decreasing from the surf zone offshore. This relationship has also been plotted in a method described by Bascom (1951). In an attempt to standardize his measurements and aid in the comparison of data from different beaches around the world, Bascom defined a "reference point" on the foreshore region of the beach where all other points could be referenced. For example, to show the trend in sediment grain size variation, Bascom defined a relative diameter where all the sediment samples' median grain sizes were divided by the median grain size of the reference point. Figure 30 shows this relationship for Bascom's data along the Pacific coast.

From Bascom's plot, the sediment variation in the cross-shore direction is obvious. The grain sizes reach a maximum size in the surf zone where there is maximum turbulence. From that point offshore, the sediment median grain sizes become increasingly finer. The sediment data from profile A was plotted in a similar manner in Figure 29. As expected, the same trend prevailed with the maximum grain size appearing in the surf zone and grain sizes decreasing offshore. However, the grain sizes did reach a point at about 2000 ft offshore where the median grain oscillated between 0.12 mm and 0.135 mm. The profile scale factor, A, followed the same trend as the median grain size diameters, as expected.

Table 2. Summary of sediment characteristics and beach slope.

Sample	x (ft)	d50	% variation	Vf	Α	slope	Std	Skew
]	(mm)	of d50 with	(ft/s)	(ft^1/3)	•	Dev	
		<u> </u>	reference		<u> </u>]	ĺ
Dune	-18.8	0.159	102	0.061	0.131		0.365	-0.082
Midshore*	47.5	0.157	100	0.060	0.130	0.022	0.380	-0.123
Surf	115.0	0.183	117	0.071	0.140	0.030	0.500	0.120
1	257.6	0.163	104	0.062	0.132	0.038	0.380	-0.105
2	286.5	0.149	95	0.056	0.126	0.040	0.388	0.194
3	404.0	0.135	86	0.051	0.121	0.030	0.430	-0.194
4	706.8	0.139	89	0.052	0.122	0.034	0.438	-0.248
5	1533.4	0.121	77	0.045	0.114	0.004	0.228	-0.139
6	2110.6	0.130	83	0.049	0.119	0.010	0.222	0.067
7	2493.8	0.127	81	0.048	0.117	0.009	0.255	-0.052
8	2876.7	0.132	84	0.050	0.119	0.009	0.273	-0.055
9	3342.1	0.129	83	0.048	0.118	0.003	0.325	-0.133
10	3959.3	0.134	86	0.050	0.120	0.008	0.325	-0.103
indicates	reference	point						<u> </u>

Figure 29. Distance offshore versus percent variation of d_{50} from reference diameter

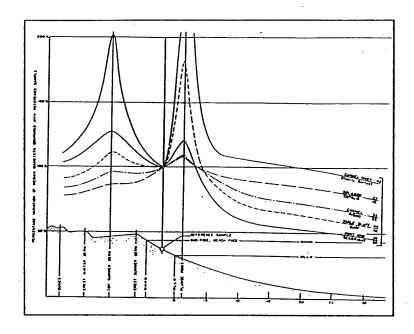


Figure 30. Distance offshore versus % Variation of d_{50} from reference diameter from Bascom (1951)

The standard deviations of the samples taken from profile A can be found in Table 2. The standard deviations of the sediments from profile A vary from about 0.22 to 0.5. These values correspond to a sample which is between perfectly sorted and well sorted. This means that the samples are poorly-graded, or their particles are close to one size.

The skewness of the samples from profile A can also be found in Table 2. Most of the samples have a negative skewness which may indicate an erosive environment. These values are very close to zero at the beginning of the profile. The skewness then seems to increase to a maximum skewness of -0.248 at about 700 ft offshore, and then the skewness decreases again. This negative skewness indicates that the sample is

skewed towards larger grain sizes, and that the finer materials have been removed from waves or currents (Dalrymple and Dean, 1996).

Beach Slope Variation

According to the Shore Protection Manual (1984), the slope of the beach depends dominantly on sediment grain size. Of course, other variables play an important role in shaping the profile of a beach such as wave energy, tides, currents and winds. The slope of Profile A changes from its steepest point in the foreshore region, to its flattest point offshore as seen in Figure 31. This change in slope also corresponds with a change in median grain size diameter along the profile. Figure 32 shows the relationship between beach slope and median grain size for Profile A.

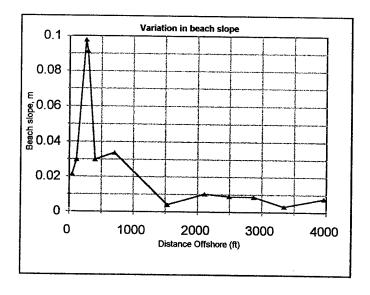


Figure 31. Variation in beach slope with distance offshore

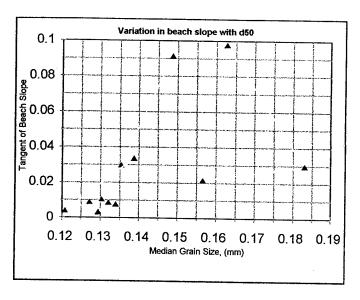


Figure 32. Variation of beach slope with median grain size

In Figure 32, the beach slope increases with an increase in median grain size.

Although no definite conclusions can be drawn from this plot, a relationship is apparent

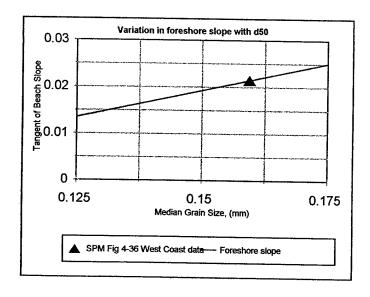


Figure 33. Median grain size versus foreshore slope comparison with SPM data

between grain size and beach slope. This figure is synonymous with Figure 34 taken from the Shore Protection Manual (1984). Figure 34 shows the relationship between foreshore slope and median grain size for beaches across the country.

In Figure 33, the foreshore slope of profile A was compared to the slope of the line in Figure 34 corresponding to the beach slopes and grain sizes of the West Coast. The West Coast data line was used in the comparison because it continued into the region of grain sizes that profile A contains. Although Figure 33 contains only one data point, and no conclusion can be drawn from this plot, it is interesting to point out that the slope of the foreshore in profile A and its corresponding grain size fall directly on the line of the West Coast data.

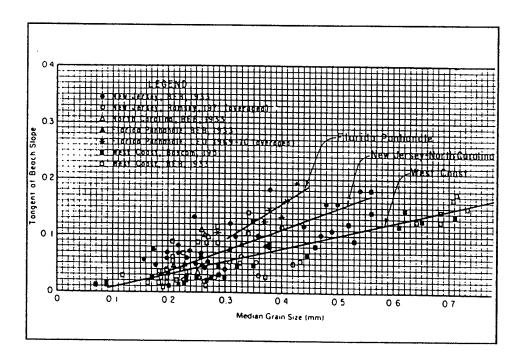


Figure 34. Median Grain size versus foreshore slope (SPM, 1984)

Equilibrium Beach Profile Prediction

As discussed before, two different methods were used to predict the equilibrium beach profile of profile A. The first method involved predicting the beach profile based on one sediment grain size obtained from the mid-shore region of the beach. The predicted profile for method 1 is based on a constant profile scale factor, A, and equation 5 was used to calculate the profile from the mean water line.

The second method accounts for variations in sediment grain size in the offshore direction. The predicted profile for method 2 is based on a profile scale factor that changes in the cross-shore direction with a change in sediment diameter. That change in profile scale factor was calculated using equation 8. The predicted profile was calculated using equation 9 from the mean water line. These calculation were completed using a spreadsheet which can be found in Appendix B-3.

Figure 35 shows a comparison of both predicted profiles against the actual profile. The results show that method 2 is a more accurate way to calculate the equilibrium beach profile. The predicted profile based on method 2 gradually changes to a flatter slope in response to the smaller median grain sizes. The predicted profile based on method 1 does not take into account this change in profile scale factor, therefore it overestimates the beach profile considerably as it moves offshore.

In order to quantify the percent error resulting from each prediction method, the area of water above each profile was calculated. This was accomplished by fitting a cubic spline through the actual profile, and both predicted profiles. With the cubic

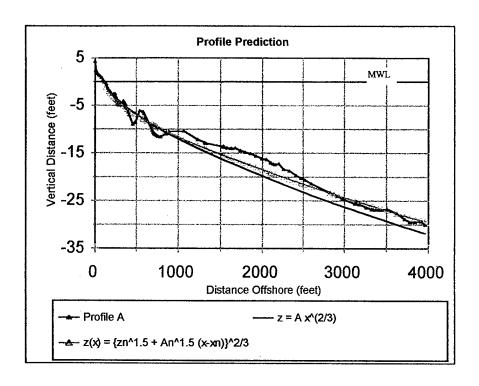


Figure 35. Predicted Profile Comparison

spline, a new set of data points representing each profile was created with equal spacing between them in the cross-shore direction. Figure 36 shows the new cubic spline line for each profile. The spacing interval was 50 ft starting at the mean water level. With equal spacing between each point, the trapezoidal rule was applied between each point in order to calculate the area in each segment. Finally, the area in all of the segments was totaled. These calculations can be found in appendices B-7 to B-9.

The percent error for each prediction method was calculated by dividing the difference in area between the actual profile and predicted profile by the area of the actual profile. The results of these calculation are shown in Table 3. As seen in the table, method 2 has considerably less error than method 1. The percent error for method

2 is 3.5%, while the error for method 1 is 10.5%. The error of method 1 is 3 times that of the error from method 2. The difference in error is equivalent to nearly 4600 cubic feet of sand per linear foot of beach. Therefore, method 2 should be the preferred method of calculating equilibrium beach profiles when the sediment data is available or when a more accurate profile prediction is required.

Table 3. Estimate of percent error for each profile prediction method.

	Profile A	Method 1:	Method 2:
		$z = A x^{(2/3)}$	$z(x) = {zn^1.5 + An^1.5 (x-xn)}^2/3$
Area of water above profile (ft^2)	66,110	73,027	68,439
Difference in Area With Profile A	N/A	6,916	2,328
% difference with Profile A	N/A	10.5%	3.5%

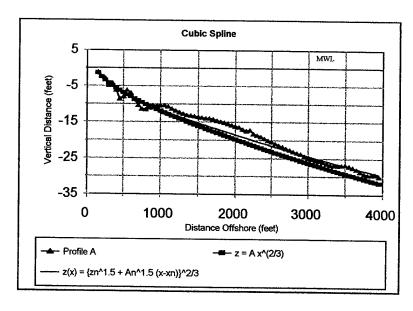


Figure 36. Cubic spline used to calculate percent error of profile predictions

Another analysis of the difference between the predicted and actual profiles was also conducted. The root mean squared distance between the actual and predicted profile was calculated using the following equation:

$$d_{rms} = ((z(x)_{predicted} - z(x)_{measured})^2)^{1/2}$$
 (Eq. 17)

The results from this calculation showed that method 2 was still more accurate than method 1 for predicting the actual beach profile. The average root mean squared distance between the predicted and actual profiles were 2.06 and 1.10 ft for methods 1 and 2, respectively. The calculations can be found in Appendix B-10.

Conclusions and Recommendations

The main objective of this project to measure an accurate equilibrium beach profile, and compare the actual profile to a predicted profile was successfully accomplished. The actual beach profile was measured using a combination of land and offshore surveying techniques. The predicted profiles were based on two methods. One method was to simply use Dean's (1997) equation for equilibrium beach profiles, $z=Ax^{2/3}$. The other method involved a more complex analysis described by Dean and Dalrymple (1996), which accounts for a variation in sediment size and profile scale factor, A, in the offshore direction

The land survey was accomplished using an electronic total station with a standard surveying rod, and the offshore survey was completed using the Texas A & M University sea sled. The sea sled is an accurate instrument for obtaining equilibrium beach profiles from the surf zone to a depth of about 35 ft. It is durable, lightweight, easy to transport, and relatively inexpensive.

The sediment analysis for profile A showed a decrease in median grain size from the surf zone towards offshore. That decrease in median grain size corresponded to a decrease in beach slope. These results were compared to similar results from Bascom (1951). Equilibrium beach profile slope is dependent on the median grain size along the profile.

Method 2 described in this report is a much more accurate method for predicting equilibrium beach profiles than method 1. The error for method 2 was 3.5 % compared

to 10.5% for method 1. The average root mean squared distance between the actual and predicted profile for method 2 was also half that of method 1. Method 2 is a more realistic representation of predicting the equilibrium beach profile. If the sediment data is available, or a more accurate profile prediction is required, method 2 should be the method of choice.

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APPENDIX

A

Erick Knezek M.E. Project 24 SEP 97

- ► Talk to Dr. Robert Bruner from C.E. Dept. about borrowing survey equipment
- Chart boat: Contact James Rouso with CBI at (512) 994-5758 or (512) 815-3196. Or call Capt. John Barrera at (512) 992-8855
- Rent Trailer from Leon Sevcik's Texaco, 2200 Longmire Dr. C.S., Tx 77845 (409)-696-0065

Equipment List:

- ► EDM (Total Station)
- Extra Batteries
- Charger
- Survey Rod
- 4 Range Poles
- ► 2 Prism reflectors (triple and regular)
- Flags
- Tacks
- notebook
- Camera & Film
- Digital camera
- Diskettes
- Underwater Camera, disposable
- Video Camera & Tapes
- Hand held Radios
- Dive Gear
- Duct tape
- ► 100 ft measuring tape
- wooden and metal stakes
- Sledge hammer
- Sled and box with tools
- Extra Wood
- Table with chair from hydrolab
- Waterproof markers
- Zip-loc storage bags
- Water
- Ice Chests
- Tarp and tie rope
- Batteries
- Plastic Straps
- Milk Crates
- Nails

APPENDIX

В

Profile A Point	H.I.	R.H.	H. Dist	:		H.A	Angle			V.A	ngle		х	Υ	Z
(#)	(feet)	(feet)	(feet)		eg.) (n			(dec.)	(deg.)	(min.) (sec.	(dec.)	(feet) -18.82	(feat) 0.00	(feet) 15.89
	4.667 4.667	4.82 8.29	18.8	82	0	0	0	0.000	-24	-59	-30	-24.992	0.00	0.00	4.31
	4.667	8.29	15.3	28	181	33	40	181.561	6	29	45	6.496	15.27	0.42	1.94
	4.667	8.29	23.9			52 43	55	180.867 180.732	3	37	30 45	3.008 1.629	23.92 35.79	0.36	1.70
	4.667 4.667	8.29 8.29	35.1 47.5		180 180	53	20	180.889	o	59	40	0.994	47.50	0.74	1.51
	4.667	8.29	62.0	09	181	9	25	181.157	0	30	25	0.507	62.08	1,25	0.93
6	4.667	8.29			181	16	55	181.282	0	-10	-35	-0.172 -0.176	79.56 97.66	1.78 3.21	0.39
	4.667 4.667	8.29 8.29			181 180	52 58	55 20	181.882 180.972	l ö	-20	-30	-0.342	115.01	1.95	0.00
9	4.667	8.29		51	181	5	0	181.083	0	-27	-10	-0.453	136.49	2.58	-0.39 -1.30
10	4.667	8.29			180	53	45	180.896 180.654	0	-44 -48	-20 -25	-0.739 -0.807	154.43	1.95	-1.72
11 12	4.667 4.667	8.29 8.29			180 180	39 41	15 45	180.696	Ö	-49	-40	-0.828	189.19	2.30	-2.05
13	4.667	8.29	205	79	180	36	55	180.615	0	-55	-5	-0.918	205.78	2.21	-2.61 -2.54
14	4.667	8.29			180	35	35 50	180.593 180.614	0	-49 -44	-15 -35	-0.821 -0.743	225.10	2.33	-2.54
15 16	4.667 4.667	8.29 8.29			180	36 21	40	180.361	1 6	-52	-10	-0.869	257.62	1.62	-3.22
17	4.667	8.29	267.	09	180	27	0	180.450	0	-57	-45	-0.963	267.08	2.10	-3.80 -4.62
18	4.667	8.29			180	30 23	45	180.513 180.397	-1	-5 -6	-15 -5	-1.088 -1.101	279.39	2.03	-4.95
19 20	4.667	8.2			180	26	35	180.443		0	-30	-1.008	308.01	2.38	-4.73
21	4.667	8.25			180	22	25	180.374		-59	-25	-0.990	312.28 329.37	2.04	-4.71 -4.65
22	4.667	8.25			180	22 23	5	180.368 180.385		-55 -46	-40 -35	-0.928 -0.776	345.46	2.32	-3.99
23	4.667	8.2			180	26	50	180.447		-48	-50	-0.814	365.67	2.85	-4.51
25	4.667	8.2	381	.97	180	22	25	180.374		-54	-20	-0.906	381.96	2.49	-5.35 -4.84
26	4.667	36.5			179	28 33	30 5	179.475 179.551		32 27	25 25	4.540	286.51	-2.63 -2.28	-4.88
27 28	4.667	36.5			179	54	50	179.914	4	17	45	4.296	302.96	-0.46	-4.83
29	4.667	36.5	313	.45	180	12	25	180.207			50	4.164	313.45	1.13	-4.76 -4.74
30	4.667				180	16 51	15	180.271 180.853			35 0	3,200	315.27 391.73	5.83	-5.65
31 32	4.667				180	55	0	180.917		59	45	2.996	404.04	6.46	-6.40
33	4.667	36.5	0 413	.89	180	1	10	180.019	2	50	50	2.847	413.89	0.14	-6.96
34	4.667				181	22 17	35 40	181.376 182.294			15	2.321	458.20 481.66	11.01 19.30	-8.96 -8.60
35 36	4.667			3.46	182 182	19	55	182.332	2 2	13		2.232	488.06	19.87	-8.50
37	4.667	36.5	0 545	.87	184	15	50	184.26	1 2	15	5	2.251	544.36	40.59	-6.08 -6.29
38 39	4.667			7.07	185 185	19 23	55 50	185.33 185.39			55 0	2.082	581.94 584.47	54.31 55.22	-6.35
40	4,667			7.57	185	26	õ	185.43		59		1.999	594,89	56.58	-6.68
41	4.66	36.5	0 617	7.77	185	14	0	185.23			0	1.867	615.19	56.35 55.64	-7.40 -8.25
42	4.66			5.26	184	59 23	25	184.98 184.39		25		1.724	638.14 693.22	53.22	-10.18
44	4.66			3.77	184	14	55	184.24	9	22	20	1.372	706.82	52.51	-10.55
45	4.66	36.5		2.16	184	12		184.20		21		1.360 1.318	710.24 716.94	52.19 88.95	-10.62 -10.90
46	4.66			0.63	187 184	4	55 55	187.07		1 19		1.292	728.78	52.01	
48	4.66			4.73	184	4	10	184.06	9	1 16	55	1.282	732.88	52.14	-11.08
49	4.66			9.38	184	6		184.10		1 14		1.239	747.46 765.36	53.61 56.45	-11.32 -11.47
50	4.66			7.44	184 184	13		184.21 184.27		1 8		1,151	790.28	59.13	
52	4.66		50 8	55.9	183	24	55	183.41	5	1 6	20	1.106	854.38	50.99	-11.01
53	4.66			64.5	184	22		184.36 184.28		1 5		1.103	861.99 874,33	65.84 65.44	
55	4.66			6.78 4.52	184			184.15		11 -		1.092	892.17	64.80	
56	4.66	7 36.	50 10	71.4	182	47	55	182.79	9	0 54	55		1070.12	52.31	
57	4.66			2.43	181 181	32		181.54 181.47		0 42		0.714	1231.98 1312.15	33.28 33.85	
58 59	4.66			2.59 29.4	181	25		181.42		0 3			1328.99	33.09	-12.96
60	4.66	7 36.	50 153	4.49	182	8	15	182.13		0 3			1533.42	57.23	
61	4,66 4.66			5.14 8.64	182			182.12 182.18		0 3	1 15		1534.08 1547.52	57.00 58.92	
62 63	4.66			1.63	182					0 2			1580.55	58.57	-13.91
64	4.66	7 36.	50 162	9.56	181					0 2			1628.58	56.44	
65 66	4.66			6.34	181					0 2			1675.38 1735.14	56.68 57.48	
67	4.66			4.67	181					0 2				58.11	-14.82
68	4.66	7 36.	50 185	7.82	181	51	25	181.85	7	0 2	2 55	0.382	1856.84	60.20	-15.14
69 70	4.66			3.33 7.22	181					0 2			1922.30 1996.07	62.90 67.7	
71	4.66	7 36.	50 204	9.65	182	2	2 40	182.04	14	0 1	8 45	0.313	2048.35	73.12	-16.34
72	4.66	7 36.	50 210	0.36	182					0 1			2098.89 2110.61	78.49 79.80	
73 74	4.66			2.12 4.77	182					0 1			2133.16	82.70	-17.27
75	4.60	7 36.	50 215	6.45	182	2 14	4 50	182.24	17	0 1	6 5	0.268	2154.79	84.5	-17.43
76						2 16	5 40	182.26	24.1	rs 4	6 5	0.268	2201.44	86.9	
77 78	4.66			3.16									2261 57] 80.//	
[/0	4.66 4.66	7 36.	50 226	33.16 33.34 335.7	182	2 1	5 55	182.2	55	0 1 0 1	3 50	0.231	2333.90	89.40 91.6	4 -18.75
79	4.66 4.66	7 36. 7 36. 7 36.	50 226 50 23 50 242	33.34 335.7 20.08	182 182	2 1/2 2 1/2 2 1/2	5 55 4 55 1 C	182.24 182.24 182.18	35 49 33	0 1 0 1 0 1	3 50 2 55 1 5	0.231 0.215 0.185	2333.90 2418.32	91.6 92.2	4 -18.75 -19.72
79 80	4.66 4.66 4.66	7 36. 7 36. 7 36. 7 36.	50 226 50 23 50 242 50 247	33.34 335.7 20.08 78.38	182 182 182	2 1:	5 55 4 55 1 C 7 40	182.24 182.24 182.13 182.13	35 49 33 28	0 1 0 1 0 1 0 1	3 50 2 55 1 5 0 5	0.231 0.215 0.185 0.168	2333.90 2418.32 2476.67	91.6 92.2 92.0	4 -18.75 0 -19.72 2 -20.25
79	4.66 4.66	7 36. 7 36. 7 36. 7 36. 7 36.	50 226 50 23 50 242 50 247 50 249	33.34 335.7 20.08	18. 18. 18. 18. 18.	2 1:	5 55 4 55 1 0 7 40 6 20 7 35	182.24 182.24 182.15 182.15 182.15 182.15	33 28 26	0 1 0 1 0 1 0 1 0 1	3 50 2 55 1 5 0 5 9 55 9 20	0.231 0.215 0.185 0.168 0.168 0.165	2333.90 2418.32 2476.67 2493.83 2525.59	91.6 92.2 92.0 91.6 93.7	4 -18.75 0 -19.72 2 -20.25 9 -20.32 7 -20.66
79 80 81 82 83	4.66 4.66 4.66 4.66 4.66 4.66	67 36. 67 36. 67 36. 67 36. 67 36. 67 36. 67 36.	50 226 50 23 50 247 50 247 50 248 50 252 50 260	335.7 20.08 78.38 95.51 27.33	182 183 183 183 183 183 183	2 19 19 2 19 2 19 2 19 2 19 2 19 2 19 2	5 55 4 55 1 0 7 40 6 20 7 35 8 30	182.24 182.24 182.13 182.13 182.13 182.13	33 28 26 42	0 1 0 1 0 1 0 1 0 0	3 50 2 55 1 5 0 5 9 55 9 20 8 5	0.231 0.215 0.185 0.168 0.165 0.156 0.156	2333.90 2418.32 2476.67 2493.83 2525.59 2605.45	91.6 92.0 92.0 91.6 93.7 97.4	4 -18.75 0 -19.72 2 -20.25 9 -20.32 7 -20.66 3 -21.39
79 80 81 82 83 84	4.66 4.66 4.66 4.66 4.66 4.66 4.66	57 36 57 36 57 36 57 36 57 36 57 36 57 36 57 36	50 226 50 23 50 242 50 247 50 248 50 252 50 260 50 283	33.34 335.7 20.08 78.38 35.51 27.33 07.27 30.99	18. 18. 18. 18. 18. 18. 18.	2 15 2 14 2 17 2 17 2 17 2 17 2 17	5 55 4 55 1 0 7 40 6 20 7 35 8 30	182.20 182.20 182.10 182.11 182.11 182.11 182.11	33 28 26 42 69	0 1 0 1 0 1 0 1 0 0	3 50 2 55 1 5 0 5 9 55 9 20	0 0.231 0 0.215 0 0.185 0 0.168 0 0.165 0 0.156 0 0.135 0 0.086	2333.90 2418.32 2476.67 2493.83 2525.59 2605.45 2828.96	91.6 92.2 92.0 91.6 93.7 97.4 107.1	4 -18.75 0 -19.72 2 -20.25 9 -20.32 7 -20.66 3 -21.39 7 -23.27
79 80 81 82 83 84 85 86	4.66 4.66 4.66 4.66 4.66 4.66 4.66 4.66	57 36, 57 36,	50 226 50 23 50 242 50 247 50 248 50 252 50 260 50 283 50 283 50 283	33.34 335.7 20.08 78.38 95.51 27.33 07.27 30.99 78.68 28.46	182 183 183 183 183 183 183 183 183	2 15 2 1- 2 1- 2 1- 2 1- 2 1- 2 1- 2 1- 2 1-	5 55 4 55 1 0 7 40 6 20 7 35 8 30 0 10 8 25 4 25	182.20 182.11 182.12 182.13 182.13 182.14 182.14 182.14 182.14 182.15 182.15 182.15 182.16	35 49 33 28 26 26 42 69 40	0 1 0 1 0 1 0 1 0 0 0 0	3 50 2 55 1 5 0 5 9 55 9 20 8 5 5 10 4 45 4 10	0.231 0.215 0.185 0.168 0.168 0.165 0.156 0.135 0.086 0.079 0.069	2333.90 2418.32 2476.67 2493.83 2525.59 2605.45 2828.96 2876.67 2926.54	91.6 92.2 92.0 91.6 93.7 97.4 107.1 107.5	4 -18.75 0 -19.72 2 -20.25 9 -20.32 7 -20.66 3 -21.39 7 -23.27 1 -23.54 6 -23.97
79 80 81 82 83 84 85 86 87	4.66 4.66 4.66 4.66 4.66 4.66 4.66 4.66	37 36, 37 36,	50 226 50 23 50 242 50 247 50 248 50 252 50 260 50 283 50 283 50 292 50 292	33.34 335.7 20.08 78.38 35.51 27.33 37.27 30.99 78.68 28.46	182 183 183 183 183 183 183 183 183 183 183	2 15 2 1- 2 1- 2 1- 2 1- 2 10 2 10 2 1- 2 10 2 1- 2 10 2 1- 2 10 2 1- 2 10 2 1- 2 10 2 1- 2 10 2 10 2 10 2 10 2 10 2 10 2 10 2 10	5 55 4 55 1 0 7 40 6 20 7 35 8 30 0 10 8 25 9 15	182.20 182.21 182.13 182.13 182.13 182.13 182.13 182.14 182.14 182.15 182.15 182.15 182.15 182.15 182.15	35 49 33 28 06 26 42 69 40 74	0 1 0 1 0 1 0 1 0 0 0 0 0 0	3 50 2 55 1 5 0 5 9 55 9 20 8 5 1 4 4 4 10 3 15	0.231 0.215 0.185 0.168 0.168 0.165 0.156 0.135 0.079 0.069 0.054	2333.90 2418.32 2476.67 2493.83 2525.59 2605.45 2828.96 2876.67 2926.54	91.6 92.2 92.0 91.6 93.7 97.4 107.1 107.5 105.9	4 -18.75 0 -19.72 2 -20.25 9 -20.32 7 -20.66 3 -21.39 7 -23.27 1 -23.54 6 -23.97 8 -24.70
79 80 81 82 83 84 85 86 87	4.66 4.66 4.66 4.66 4.66 4.66 4.66 4.66	57 36, 57 36,	50 226 50 23 50 242 50 247 50 248 50 252 50 260 50 283 50 283 50 292 50 293 50 313	33.34 335.7 20.08 78.38 95.51 27.33 07.27 30.99 78.68 28.46 988.8 30.98	182 183 183 183 183 183 183 183 183 183 184 184 185	2 15 2 1- 2 1- 2 1- 2 10 2 10 2 10 2 11 3 1 5 1 4	5 55 4 55 1 0 7 40 6 20 7 35 8 30 0 10 8 25 9 15 3 55	182.20 182.21 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11	35 49 33 28 06 26 42 59 40 74 88 32	0 1 0 1 0 1 0 1 0 0 0 0 0 0 0 0	3 50 2 55 1 5 0 5 9 50 9 20 8 5 5 10 4 40 4 10 3 15 2 5	0.231 0.215 0.185 0.185 0.168 0.165 0.156 0.156 0.0156 0.0086 0.0096 0.0096 0.0096 0.0096 0.0096 0.0096	2333.90 2418.32 2476.67 2493.83 2525.59 2605.45 2828.96 2876.67 2926.54 2987.00 3129.55	91.6 92.2 92.0 91.6 93.7 97.4 107.1 107.5 105.9 103.6 94.6	4 -18.75 0 -19.72 2 -20.25 9 -20.32 7 -20.66 3 -21.39 7 -23.27 1 -23.54 6 -23.97 6 -24.70 3 -25.62
79 80 81 82 83 84 85 86 87 88 89	4.66 4.66 4.66 4.66 4.66 4.66 4.66 4.66	37 36, 37	50 226 50 23 50 242 50 247 50 245 50 25 50 28 50 28 50 28 50 28 50 28 50 31 50 31 50 31 50 31	33.34 335.7 20.08 78.38 95.51 27.33 07.27 30.99 78.68 28.46 988.8 30.98 31.32 41.43	182 182 183 183 183 183 183 183 183 183 184 185 186 186 186 187 188 188 188 188 188 188 188 188 188	2 15 2 1- 2 1- 2 1- 2 1- 2 1- 2 1- 2 1- 2 1-	5 55 4 55 1 (7 40 6 20 7 35 8 30 0 10 8 25 4 25 9 15 3 56 3 50 2 (182.24 182.24 182.14 182.15 182.15 182.15 182.15 182.15 182.16 182.16 181.76 181.77	35 49 33 28 06 26 42 59 40 74 88 32 32	0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0	3 50 2 55 1 5 0 5 9 55 9 20 8 5 5 10 4 45 4 10 3 15 2 5 2 5 2 5 3 15 4 45 4 45 4 45 2 5 2 5 3 15 3 15 4 45 4 45 4 45 4 45 4 45 4 45 4 45 4	0.231 0.231 0.215 0.185 0.165 0.165 0.165 0.135 0.036 0.036 0.036 0.036 0.036	2333.90 2418.32 2476.67 2493.83 2525.59 2605.45 2828.96 2876.67 2926.54 2987.00 3129.55 3129.89 3140.05	91.6 92.2 92.0 91.6 93.7 97.4 107.1 107.5 105.9 103.6 94.6 94.6	4 -18.75 0 -19.72 2 -20.25 9 -20.32 7 -20.66 3 -21.39 7 -23.27 1 -23.54 6 -23.97 8 -24.70 3 -25.62 4 -25.47 9 -25.62
79 80 81 82 83 84 85 86 87 88 89 90	4.66 4.66 4.66 4.66 4.66 4.66 4.66 4.66	37 36, 37	50 226 50 23 50 242 50 245 50 245 50 25 50 283 50 283 50 283 50 283 50 313 50 313 50 313 50 313	3.34 335.7 20.08 78.38 95.51 27.33 07.27 30.99 78.68 28.46 988.8 30.98 31.32 41.43	182 182 183 183 183 183 183 183 183 184 186 188 188 188 188 188 188 188	2 19 2 1- 2 1- 2 10 2 10 2 10 2 10 2 10 2 11 4 11 4 11 4 11 3	5 55 4 55 1 (7 40 6 20 7 35 8 30 0 10 8 25 9 15 3 55 3 55 2 (6 35	182.20 182.21 182.13 182.13 182.13 182.14 182.14 182.15 182.15 182.15 182.15 182.15 182.15 182.15 182.15 182.15 181.75 181.75 181.75	35 49 33 28 06 26 42 59 40 74 88 32 32 32	0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0	3 50 2 55 1 5 9 55 9 20 8 5 5 10 4 45 4 10 3 15 2 15 2 15 2 15	0.2311 0.215 0.185 0.1688 0.1688 0.1688 0.1688 0.0185	2333.90 2418.32 2476.67 2493.83 2525.59 2605.45 2876.67 2926.54 2987.00 3129.55 3140.05 3179.30	91.6 92.2 92.0 91.6 93.7 97.4 107.1 107.5 105.9 94.6 94.6 93.1 89.3	4 -18.75 -19.72 2 -20.25 7 -20.66 3 -21.39 7 -23.27 1 -23.54 6 -23.97 8 -24.70 9 -25.62 4 -25.47 9 -25.62 5 -25.75
79 80 81 82 83 84 85 86 87 88 89 90 91	4.66 4.66 4.66 4.66 4.66 4.66 4.66 4.66	37 36, 37	50 226 50 23 50 242 50 245 50 245 50 255 50 265 50 285 50 295 50 295 50 313 50 313 50 313 50 313 50 313	3.34 3.35.7 20.08 78.38 95.51 27.33 07.27 30.99 78.68 30.98 31.32 41.43 90.56 59.87	182 183 183 183 183 183 183 183 184 184 185 186 186 186 187 187 188 188 188 188 188 188 188 188	18 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	5 55 55 55 55 55 55 55 55 55 55 55 55 5	182 20 182 2 182 1 182 1	35 49 33 28 36 26 42 69 40 74 88 32 32 32 32 30 10 40	0 1 0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0	3 50 2 55 1 5 0 5 9 55 9 20 8 5 1 4 45 4 10 3 11 2 1 2 1 2 1 1 5 1 1	0.231 0.215 0.165 0.1685 0.1685 0.1685 0.1685 0.1585 0.1585 0.0385 0	2333.90 2418.32 2476.67 2493.83 2525.59 2805.45 2828.96 2926.54 2987.00 3129.89 3129.89 3140.05 3179.30	91.6 92.2 92.0 91.6 93.7 97.4 107.1 107.5 105.9 103.6 94.6 93.1 89.3	4 -18.75 1-19.72 2 -20.25 9 -20.32 7 -20.66 3 -21.39 7 -23.27 1 -23.54 6 -23.97 6 -24.70 3 -25.62 4 -25.47 9 -25.62 5 -25.75 4 -26.41
79 80 81 82 83 84 85 86 87 88 89 90 91 92 93	4.66 4.66 4.66 4.66 4.66 4.66 4.66 4.66	37 36 37 37 36 37 37 36 37	50	33.34 335.7 20.08 878.38 95.51 27.33 27.27 30.99 78.68 8.09 88.8 88.09 88.8 80.98 83.1,32 84.4 85.8 86.6 86.6 86.6 86.6 86.6 86.6 86.6	182 183 183 183 183 183 183 183 183 183 183	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	5 55 4 55 1 0 7 40 6 20 7 35 8 30 0 10 8 25 9 15 3 55 3 55 3 55 6 26 7 36 6 26	182.24 182.22 182.13 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 181.77 181.77 181.77 181.61 181.77 181.61 181.61	35 49 33 28 26 26 42 59 40 74 88 32 32 32 32 30 67	0 1 0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0	3 50 2 55 1 5 9 55 9 20 8 5 5 10 4 45 4 10 3 15 2 15 1 5 1 10 0 4	0.2311 0.21516 0.1855 0.1855 0.1655 0.1655 0.1556 0.1565 0.035	2333.90 2418.32 2476.67 2493.83 2525.59 2805.45 2828.96 2876.67 2987.00 3129.89 3140.05 3179.30 3258.84 3342.08	91.6 92.2 92.0 91.6 93.7 97.4 107.1 107.5 105.9 103.6 94.6 93.1 89.3 81.9 74.9	4 -18.75 -19.72 2 -20.25 9 -20.32 7 -20.66 3 -21.39 7 -23.27 1 -23.54 6 -23.97 8 -24.70 3 -25.62 4 -25.47 9 -25.62 4 -26.41 8 -26.80 0 -26.79
79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94	4.66 4.66 4.66 4.66 4.66 4.66 4.66 4.66	37 36 37 37 36 37 37 36 37	50 226 50 23 50 244 50 245 50 255 50 255 50 265 50 285 50 285 50 285 50 295 50 311 50 314 50 312 50 33 50	33.34 335.7 20.08 8.88 95.51 27.33 27.27 30.7 27.33 27.27 30.9 99.7 8.68 80.9 88.8 80.9 88.8 80.9 88.8 80.9 88.8 80.9 80.9	182 182 182 182 182 183 183 183 183 184 185 188 188 188 188 188 188 188 188 188	2 152 142 142 142 142 142 142 142 142 142 14	55 555 555 555 555 555 555 555 555 555	182.24 182.24 182.14 182.15 182.15 182.15 182.15 182.15 182.15 182.15 181.77 181.77 181.77 181.77 181.77 181.70 181.40 18	55 49 33 33 28 66 626 42 29 40 74 88 32 32 32 40 40 40 40 40 40 40 40 40 40	0 1 0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0	33 502 2 553 2 553 3 500 6 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	0.2311 0.2313 0.21515 0.165	233.90 2418.32 2476.67 2493.83 2525.59 2805.45 2828.96 2870.00 3129.89 3140.05 3129.89 3140.05 3129.89 3340.03 3325.89 3342.83	91.6 92.2 92.0 91.6 93.7 97.4 107.1 107.5 105.9 103.6 94.6 94.6 93.1 89.3 81.9 74.9 73.9 71.5	4 -18.75 0 -19.72 2 -20.25 9 -20.32 7 -20.66 3 -21.39 7 -20.66 6 -23.97 1 -23.54 6 -23.97 6 -24.70 3 -25.62 4 -26.47 9 -25.62 5 -25.75 4 -26.41 2 -26.80 0 -26.87 9 -26.87
79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96	4.66 4.66 4.66 4.66 4.66 4.66 4.66 4.66	67 36 67	50	33.344 78.385.51 36.55 37.30 3	182 182 183 183 183 183 183 184 185 188 188 188 188 188 188 188 188 188	2 152 142 142 142 142 142 142 142 142 142 14	5 55 4 55 1 0 7 40 6 20 7 35 8 30 0 10 8 25 9 15 3 55 3 55 3 55 6 26 7 36 6 26	182.24 182.14 182.15 182.15 182.15 182.15 182.15 182.15 182.15 182.15 182.15 182.15 181.7	55 55 55 55 55 55 55 55	0 1 0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0	3 50 2 55 1 5 9 55 9 20 8 5 5 10 4 45 4 10 3 15 2 15 1 5 1 10 0 4	0.2311 0.2313 0.2155 0.1855 0.1855 0.1855 0.1555 0.1555 0.0325 0.0795 0.0545 0.0325	2333 90 2418.32 2476.67 2493.83 2525.59 2805.45 2828.96 2876.67 3129.55 3140.05 3179.30 3140.05 3179.30 3325.59 3342.88 3368.25	91.6 92.2 92.0 93.7 97.4 107.1 107.5 105.9 103.6 94.6 94.6 94.7 89.3 81.9 74.9 73.9	4 -18.75 -19.72 2 -20.25 9 -20.32 7 -20.66 9 -20.32 7 -23.27 1 -23.54 6 -23.97 6 -23.97 1 -25.62 4 -25.47 9 -25.62 5 -25.75 4 -26.80 0 -26.80 0 -26.86
79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96	4.66 4.66 4.66 4.66 4.66 4.66 4.66 4.66	67 36, 67	50 226 50 23 50 245 50 245 50 245 50 25 50 26 50 26 50 26 50 26 50 31 50 31 50 31 50 32 50 33 50 30 50 30 50 30 50 30 50 30 50 30 50 30 50 30 50 30 50	33.34 335.7 78.38 95.51 27.33 37.27 360.99 978.68 88.0.98 88.00 88.00 88.00 88.00 88 88.00 88 88.00 88 88.00 88 88 88 88 88 88	182 183 183 183 183 183 183 184 185 186 188 188 188 188 188 188 188 188 188	2 192 142 152 162 163 163 163 163 163 163 163 163 163 163	55 555 555 555 555 555 555 555 555 555	182.24 182.24 182.15 182.11 182.15 182.15 182.15 182.16 182.16 182.16 182.16 182.17 181.76 181.77 181.76 181.81 181.20	55 149 133 128 1	0 1 1 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0	33 502 555 51 1 5 5 5 1 1 1 1 5 5 1 1 1 1 1 1	0.2311	233.9 0 2418.32 2418.32 2476.67 2493.83 2525.59 2525.59 2828.98 2828.98 287.00 343.29 2525.59 3129.55	91.6 92.2 92.0 91.6 93.7 97.4 107.1 107.5 105.9 103.6 94.6 93.1 89.3 81.9 74.9 71.9 68.1 66.1	4 -18.75 2 -19.72 2 -20.25 9 -20.32 7 -20.66 3 -21.39 7 -23.27 1 -23.54 6 -24.70 3 -25.62 4 -25.47 9 -25.62 5 -25.62 5 -25.62 6 -26.80 0 -26.79 0 -26.86 0 -26.
79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98	4.666 4.666	777 36,77	50	33.34 335.7 78.38 95.51 27.33 37.27 360.99 988.8 830.98 830.98 830.98 841.43 841.43 869.01 97.21 869.01 869	182 183 183 183 183 183 183 184 185 188 188 188 188 188 188 188 188 188	2 192 1 1 2 2 1 1 2 2 1 1 2 2 1 1 1 1 1	55 555 555 555 555 555 555 555 555 555	182.24 182.24 182.14 182.15 182.15 182.15 182.15 182.16 182.16 182.16 182.16 181.77 18	55 49 33 28 32 28 32 28 32 32	0 1 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0	33 502 555 11 5 10 10 10 10 10 10 10 10 10 10 10 10 10	0.231 0.215 0.185 0.18	2333.90 2418.32 2476.67 2493.83 2525.99 2605.45 2828.96 2926.64 2987.00 3129.59 3129.89 3179.30 325.58 3440.55 3368.25 3445.50 369.25	91.6 92.2 92.0 91.6 93.7 97.4 107.1 107.5 105.9 103.6 94.6 93.1 89.3 81.9 73.9 73.9 68.1 68.1	4 -18.75 -19.72 -19.72 -19.72 -20.32 -7 -20.66 -20.32 -7 -20.66 -20.66 -20.66 -20.97 -20.57
79 80 81 82 83 84 85 86 87 88 89 90 91 92 83 94 95 96 97 98	4.666 4.666	777 36.77	500 226 500 23 500 245 500 245 500 25 500 26 500 26 500 28 500 28 500 28 500 28 500 31 500 31 500 31 500 31 500 33 500 33 500 33 500 34 500 35 500 36 500	33.344 335.77 20.08 78.38 95.51 27.33 30.79 77.27 33.09 978.68 830.98 830.98 830.98 830.98 8441.43 849.93 8	182 183 183 183 183 183 183 184 185 188 188 188 188 188 188 188 188 188	2 192 1 1 2 2 1 1 2 2 1 1 2 2 1 1 1 1 1	55 555 555 555 555 555 555 555 555 555	182.24 182.24 182.15 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 183.11 184.17 181.41	55 49 33 32 32 32 32 32 32 3	0 1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	33 502 555 51 1 5 5 5 1 1 1 1 5 5 1 1 1 1 1 1	0.2311	2333.90 2418.32 2476.67 2493.83 2525.99 2605.45 2828.96 2876.67 2926.54 3129.59 3129.59 3140.05 3342.08 3342.08 3345.59 3342.08 336.25 336.25 336.25 336.25 336.25 336.25 336.25 336.25 336.25	91.6 92.2 92.0 91.6 93.7 97.4 107.1 107.5 105.9 103.6 94.6 94.6 94.6 94.6 94.6 94.6 94.6 94	4 -18.75 2 -19.72 2 -20.25 9 -20.32 7 -20.66 3 -21.39 7 -23.27 1 -23.54 6 -23.97 6 -24.70 3 -25.62 5 -25.75 4 -26.41 8 -26.87 9 -26.62 1 -26.66 1 -26.67 9 -26.62 1 -26.76 4 -26.87 4 -26.87
79 80 81 82 83 84 85 86 87 90 91 92 93 94 95 96 99 100 101 102	4.666 4.666	777 36.77	50 226 50 245 50 245 50 265 50 315 50 315	33.34 335.7 200.08 78.38 95.51 307.2 77.30 307.2 77.30 30.9 99.7 8.68 8.60 9.8 8.6 9.5 9.7 8.6 9.6 9.7 8.6 9.6 9.6 9.6 9.6 9.6 9.6 9.6 9.6 9.6 9	182 183 183 183 183 183 183 183 184 188 188 188 188 188 188 188 188 188	2 152 142 142 142 143 143 143 143 143 143 143 143 143 143	55 555 555 555 555 555 555 555 555 555	182.24 182.24 182.19 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 183.17 181.67	55 19 19 33 32 28 20 22 59 40 74 40 32 32 32 32 32 32 32 32 32 32	0 1 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0	33 502 22 55 1	0	233.90 2476.67 2493.83 257.65 257.59 2493.83 257.50 2493.83 257.50 257.5	91.6 92.2 92.0 91.6 93.7 97.4 107.5 105.9 103.6 94.6 94.6 94.6 94.7 103.6 94.6 93.1 89.3 74.9 71.5 68.1 93.8 93.8 93.8 93.8 93.8 93.8 93.8 93.8	4 -18.75 9 -20.3227 7 -23.27 1 -23.27 1 -23.54 6 -23.97 6 -24.70 3 -25.62 5 -25.62 5 -25.62 5 -25.62 5 -25.62 6 -26.41 6 -26.67 6 -26.67 6 -26.65 6 -26.85 6 -26.85
79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 99 99	4.666 4.686	777 36.77	500 226 500 23 500 244 500 245 500 245 500 265 500 265 500 265 500 265 500 265 500 265 500 265 500 265 500 265 500 311 500 311 500 312 500 313 500 315 500	33.34 335.7 20.08 78.38 35.51 27.33 37.27 30.99 78.68 80.98 80	182 188 182 182 183 183 184 185 188 188 188 188 188 188 188 188 188	2 192 1 1 2 2 1 1 2 2 1 1 1 1 1 1 1 1 1	55 555 555 555 555 555 555 555 555 555	182.24 182.24 182.19 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 182.11 183.17 181.67	55 19 33 33 36 26 26 42 59 40 40 40 40 40 40 40 40 40 40	0 1 1 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0	33 5022 555 11 5 50 5 50 50 50 50 50 50 50 50 50 50 50	0,2313	233.90 2476.67 2493.83 2476.67 2493.83 2525.99 2525.99 2505.45 2525.99	91.6 92.2 92.0 93.7 93.7 107.1 107.5 105.9 103.6 94.6 94.6 93.1 74.9 74.9 74.9 74.9 74.9 74.9 74.9 74.9	4 -18.75 9 -20.32 7 -20.32 9 -20.32 9 -20.32 10 -20.32 11 -23.54 12 -23.27 13 -23.27 14 -25.47 15 -23.47 16 -24.70 17 -23.62 17 -23.62 18 -23.97 19 -20.86 10 -26.87 10 -26.87 10 -26.87 11 -26.87 11 -26.87 12 -26.87 13 -26.80 14 -26.87 15 -26.87 16 -26.87 17 -26.87 17 -27.61 18 -28.87 19 -28.87 10 -28.87 11 -28.87 11 -28.87 12 -28.87 13 -28.87 14 -28.87 15 -29.44 16 -26.87 17 -26.87 17 -26.87 18 -26.87 19 -26.87 10 -26.87 10 -26.87 10 -26.87 11 -26.87 11 -26.87 12 -26.87 13 -26.87 14 -26.87 15 -26.87 16 -26.87 17 -26.87 17 -26.87 18 -26.87 19 -26.87 10 -2

rofile B Point	H.1.	R.H.	H. Dist.		H.A				V.Aı		(4-1)	X (feet)	Y (feet)	Z (feet)
(#)	(feet)	(feet) 4,82	(feet)	(deg.)	(min.)	(sec.)	(dec.)	(deg.)	(min.)	(sec.)	(dec.)	-18.82	300.96	20.₹1
S 1	4.67 4.67	8.29	18.82	0	0	0	0.000	-24	-59	-30	-24.992	0.00	300.96	4.31 1.07
	4.67	8.29	25.42	177	26	0	177,433	0	51 4	55 50	0.865	25.39 38.01	299.82 299.95	0.74
	4.67	8.29	38.02 50.13	178 179	28 5	25 30	178.474 179.092	0	5	45	0.096	50.12	300.17	0.77
	4.67	8,29 8,29	60.62	179	11	49	179.197	0	10	40	0.178	60.61	300.11	0.88
;	4.67	8.29	74.33	178	26	10	178.436	0	10	55	0.182	74.30 88.48	298.93 298.86	0.92
	4.67	8.29	88,5	178	38	35	178.643 178.717	0	-8	20 -25	-0.139 -0.140	101.77	298.68	0.44
	4.67	8.29 8.29	101.8 113.07	178 178	43 59	0 50	178.997	ő	-22	-15	-0.371	113.05	298.98	-0.04
-	4.67	8.29	125.37	178	57	55	178.965	0	-32	-45	-0.546	125.35	298.70	-0.51
10	4.67	8.29	136.17	178	38	10	178.636	0		-45 -25	-0.579 -0.724	136.13 146.25	297.72 299.03	-0.69 -1.16
11	4.67	8,29	146.26 157.28	179 179	14	40 30	179.244 179.025	00		-15	-0.988	157.26	298.28	-2.02
13	4,67 4,67	8.29 8.29	173.61	178	51	20	178.856	ő		Ö	-0.050	173.58	297.49	0.54
14	4.67	8.29	188.48	178	45	55	178.765	-1	0		-1.004	188.44	296.90 295.59	-2.62 -3.05
15	4.67	8.29	202.79	178	28 9	55 20	178.482 178.156	-1	-3 -2	-25 -5	-1.057 -1.035	202.72	293.88	-3.29
16	4.67 4.67	8.29 8.29	220.08 239.64	178 177	41	30	177.692	1 0			-0.919	239.45	291.31	-3.16
18	4.67	8.29	257.01	177	13	25	177.224	0		-5	-0.951	256.71	288.51	-3,58 -4,26
19	4.67	8.29	268.73	177	53	45	177.896 178.104	-1			-1.056 -1.175	268.55 282.19	291.09 291.62	-5.10
20	4.67 4.67	8.29 8.29	282.34 292.61	178 178	6 38	15 55	178.649	-1			-1.214	292.53	294.06	-5.51
21 22	4.67	8.29	302.66	179	30	55	179.515	-1	-11		-1.190	302.65	298.40	-5.60
23	4.67	8.29	314.98	179	49	3 5	179.826				-1.101	314.98	300.01 299.73	-5.37 -5.12
24	4.67	8.29	330.25	179	47	10 50	179.786 179.614				-1.007 -0.861	330.25 353.33	298.58	-4.62
25 26	4.67 4.67	8.29 8.29	353.34 372.73	179 179	36 30		179.503				-0.906	372.72	297.73	-5.20
27	4.67	8.29	391.27	179	9	40	179.161			-20	-1.006	391.23	295.23	-6.18
28	4.67	8.29	398.9	178	51	10	178.853				-1.056 -1.019	398.82 391.52	292.97 288.37	-6.66 -6.28
29	4.67	8.29 8.29	391.72 401.4	178 178	9 37		178.158				-1.019	401.28	291.30	-6.52
30 31	4.67 4.67	8.29	415.29		55	25	177.924			0	-1.150	415.02	285.91	-7.65
32	4.67	8.29	420.08	177	52	5	177.868	-			-1.171	419.79 429.55	285.33 283.27	-7.90 -8.41
33	4.67	8.29	429.91		38 59							434.99	283.27	-8.41 -8.71
34 35	4.67 4.67	8.29 8.29	435.59 445.48		35			j -	1 -16	-45	-1.279	444.69	274.51	-9.26
36	4,67	36.50	488.34	185		10	185.05	3	2 1			486.44	343.97 347.52	-8.90 -7.12
37	4.67	36.50			55				2 10	30		535.48 552.65	347.52 349.23	
38 39	4.67 4.67	36.50 36.50			59					5 0	2.083	569.80	350.76	-6.73
40	4.67	36.50			59	55	184.99	9	1 5	3 25	1.890	603.96	353.79	
41	4.67	36.50			59				1 4			620.07 641.31	355.13 357.15	
42	4.67	36.50 36.50				25			1 3 1 3			663.08	359.21	
43 44	4.67 4.67	36.50			 				1 2		1.460	676.02	360,68	-10.23
45	4.67	36.50	720.42	185		4 5	185.06	3	1 1			717.60	364.60	
46	4.67	36.50				4 (3 55			1 1	1 50 7 50		741.24 764.70	366.68 368.74	
47 48	4.67 4.67	36.50 36.50				3 55 3 25				4 5		793.65	371.19	-12.48
49	4.67					3 25			1	3 50	1.064	809.94	372.63	
50	4.67					2 40				3 40		831.86 837.61	374.39 374.88	
51 52	4.67					2 35 6 15				2 10			378.39	
53	4.67								1	0 (1.001	952.01	371.13	
54	4.67	36.50	1109.5	5 182					0 4		0.818		344.76	
55	4.67									3 30 9 25			331.54 314.05	
56 57	4.67						179.40			3 1	0.554	1415.59	286.14	-13.83
58	4.67	36.50	1489.8							0 2			272.50	
59	4.67						0 178.58 0 178.18			9 (0.483		262.45 248.98	
60 61	4.67									4 5			241.37	-15.24
62	4.67	36.5	1750.9	3 177						3 3			239.64	
63	4.67					4 2	5 178.07 0 178.21			3 4	0.383		240.46 243.58	
64 65	4.67					3 1			0 2	0 3		1918.57	252.54	-16.08
66	4.67	36.5	0 1961.1	3 178	3 4	8 1	5 178.80	4	0 1	9	5 0.318	1960.70	260.03	
67	4.67					7 2 0 5				8 1 6 4			270.13 283.3	
68 69	4.67					2 2				5 1		2153.47	296.10	-17.97
70	4.67	36.5	0 2227.8	2 180) 1	5 5	5 180.26	5	0 1	3 4	0.228	2227.80	311.2	7 -18.66
71	4.6					9 <u>5</u>				1 5			327.76 339.60	
72 73	4.6					5 4 7 3				9 4		2452.75	349.1	
74	4.6	7 36.5	0 2524.5	7 18	1 1	5	0 181.25	0	0	8 2	0.139	2523.97	356.0	3 -21.40
75	4.6					5 4			임		0 0.128 5 0.110		358.19 354.9	
76 77	4.6			4 18 1 18			5 181.16 0 181.03		0		0 0.094		349.9	
78	4.6		0 2750.6	1 18		5 4	5 180.92	9	0	5 2	0.089	2750.25	345.5	6 -23.2
79	4.6	7 36.5	0 2794.5	8 18	0 4	7 5	0 180.79		0		5 0.082			
80 81	4.6						5 180.60 0 180.50		0		0 0.075			
82	4.6						5 180.8		0	3 5	0.064	1 2952.83	346.8	5 -24.2
83	4.6	7 36.5	0 3052.0	5 17	9 5	4 2	0 179.90		0	2	5 0.03	3052.05		
84 85	4.6						5 179.74 0 179.6		0		5 0.033 0 0.028		287.3 279.5	
86	4.6						0 179.4		ŏ	1)	0.01		270.3	7 -26,6
87	4.6	7 36.5	0 3207.4	9 17	9 1	18 2	5 179.3)7	0	1	0.01	7 3207.26	262.1	6 -26.5
88	4.6			5 17	9 -		0 179.1		0		5 0.010			
89	4.6						0 179.0 0 178.9		0	0	5 0.00 5 0.00			
ion	4.6						0 178.7		ö	0 -2	0.00	3369.07	228.4	3 -27.8
90 91	4.6	7 36.5	0 3413.6	57 17	8 :	37 5	0 178.6	31	0	0 -2	0.00	6 3412.69	219.3	8 -27.8
91 92		7 36.5					0 178.5		0		0 -0.00			
91 92 93	4.6			79 17	o1 '	16] 4	10 178.2	(0)	0	-11	0.01			
91 92 93 94	4.6 4.6	7 36.5					20 178 O	89	O	-11	01 -0 01	7 3581.28	1814	*DI ~ZD □
91 92 93	4.6	7 36.5 7 36.5	0 3583.2	27 17	8	5 2	20 178.0 10 177.9		0		0 -0.01 5 -0.02	1 3636.35	168.8	6 -28.8
91 92 93 94 95 96 97	4.6 4.6 4.6 4.6 4.6	7 36.5 7 36.5 7 36.5 7 36.5	0 3583.2 0 3638.2 0 3711.4	27 17 75 17 48 17	8 7 7	5 2 55 41 2	10 177.9 25 177.6	19 90	0	-1 -1 -1 -1	5 -0.02 5 -0.02	1 3636.35 6 3708.46	168.8 151.3	6 -28.8 8 -29.2
91 92 93 94 95 96	4.6 4.6 4.6 4.6	7 36.5 7 36.5 7 36.5 7 36.5 7 36.5	50 3583.2 50 3638.2 50 3711.4 50 3762.0	27 17 75 17 48 17 07 17	8 7 : 7 :	5 2 55 41 2 33	0 177.9	19 90 53	0	-1 - -1 -3 -2 -	5 -0.02	1 3636.35 6 3708.46 6 3758.64	168.8 151.3 140.3	6 -28.8 8 -29.2 2 -29.8

Predic	ted Pro	ofile Calc		Z = A x^2/3	slope	A		Eq.5	Sample
x (ft) -18	.82	ft) 15.889	MWL	A=.130 ft^1/3	m -0.395	(ft^1/3) 0.131	A(y) 0.131	z (ft)	15.89
0	0.00	4.312 2.416					0.130 0.130		
23	5.27 3.92	1.943					0.130		
	5.79 7.50	1.705 1.512			-0.022	0.130	0.130 0.130		1.51
67	2.08	1.237					0.132 0.134		}
	9.56 7.66	0.927		ļ			0.137		000
	5.01 6.49	0.001 -0.391	0.00	0.00	-0.030	0.140	0.140 0.139	0.00 -1.08	
154	4.43	-1.304	0.00	-1.50	1		0.138 0.137	-1.61 -2.03	
	0.91 9.19	-1.720 -2.046	0.00	-1.89 -2.29	Ì		0.136	-2.44	:
	5.78 5.10	-2.610 -2.538	0.00	-2.62 -2.98			0.135 0.134	-2.78 -3.15	
	3.24	-2.467	0.00	-3.30	rl .		0.133	-3.48	
	7.62 7.08	-3.222 -3.799	0.00			0.132	0.132 0.130	-3.88	31
27	9.39	-4.616	0.00	-3.89			0.128 0.125		
	3.26 8.01	-4.950 -4.733	0.00	-4.33	3		0.122	-4.49)
	2.28 9.37	-4.710 -4.646	0.00			1	0.121		
34	5.46	-3.994	0.00	-4.87	7		0.115	-4.96	
	5.67 1.96	-4.507 -5.349	0.00			ĺ	0.111	-5.3	7
28	6.51	-4.840	0.00	-4.00		0.126	0.126		
	1.30	-4.883 -4.827	0.00	-4.2	5		0.126	-4.5	в] .
31	3.45 15.27	-4.762 -4.744	0.00	-4.4			0.125		
39	1.73	-5.652	0.00	-5.5	0	, , , ,	0.121	-5.7	4]
	04.04 13.89	-6.402 -6.962				0.12	0.12	-5.9	9
45	58.20	-8.961	0.00	o -6.3	5	ļ	0.12		
48	31.66 38.06	-8.596 -8.498	0.0	-6.7	2	İ	0.12	-6.8	1
	44.36 81.94	-6.077 -6.288					0.12		
56	84.47	-6.350	0.0	7.8	3	1	0.12	2 -7.8	2
	94.89 15.19	-6.681 -7.398					0,12 0.12		
63	38.14	-8.254	0.0	0 -8.4		l	0.12		
	93.22 06.82	-10.180 -10.548	0.0	0 -9.1	4 -0.03	4 0.12	2 0.12	2 -9.0	1 -10.55
	10.24 16.94	-10.622 -10.903					0.12		
7.	28.78	-11.05	1 0.0	0 -9.3	6		0.12 0.12	2 -9.2	
	32.88 47.46	-11.08 -11.31				1	0.12	2 -9.4	io] [
	65.36 90.28	-11.46 -11.59				1	0.12		
8	54.38	-11.00	7 0.0	-10.6	io	1	0.12	1 -10.3	se[
	61.99 74.33	-10.88 -10.71				1	0.12	1 -10.5	3
	92.17 70.12	-10.47 -10.40				1	0.12 0.11		
12	31.98	-12.16	6 0.0	0 -13.9	95	.]	0.11	7 -13.3	99
	12.15 28.99	-12.79 -12.95				1	0.11 0.11		08
15	33.42	-13.68	4 0.0	0 -16.3	-0.00	0.11	4 0.11 0.11		
	34.08 47.52	-13.56 -13.74		00 -16.4	17	1	0.11	4 -15.5	58
	80.55 28.58	-13.91 -14.01					0.11		
16	75.38	-13.94	9 0.0	00 -17.4	14	1	0.11	15 -16.4	
	35.14 93.73	-14.47 -14.81	8 0.0	00 -18.3	31		0.11 0.11	6 -17.	17
18	356.84 322.30	-15.13 -15.58	7 0.0				0.11		
19	96.07	-16.14	4 0.0	00 -19.	75		0.11 0.11	.18. -18.	44
)48.35)98.89	-16.34 -16.98	2 0.0	oo -20.√	46		0.11	18 -19.	08
	110.61 133.16	-17.12 -17.27				10 0.1	19 0.11		
21	154.79	-17.43	2 0.0	00 -20.	85		0.1° 0.1°	18 -19.	43
22	201.44 261.57	-17.21 -18.41	3 0.1	00 -21.	57		0.1	18 -20.	08
23	333.90 418.32	-18.74 -19.71	15 0.0	00 -22.	05		0.1 0.1		
24	476.67	-20.25	52 0.	00 -22.	98		0.1	17 -21.	35
	493.83 525.59	-20.32 -20.65		00 -23. 00 -23.		0.1	17 0.1 0.1		
26	60 5.45	-21.39 -23.26	90 0.	00 -23. 00 -25.	81		0.1		
28	828.96 876.67	-23.54	13 0.	00 -25.	51 -0.0	0.1	19 0.1	19 -23.	63 -23.54
	926.54 987.00	-23.9 -24.6		00 -25. 00 -26.			0.1		
3.	129.55	-25.63	24 0.	00 -27.	05		0.1	19 -25.	03
	129.89 140.05	-25.4 -25.6	17] 0.	00 -27. 00 -27.	.11]		0.1 0.1	19 -25.	.09)
3	179.30 258.84	-25.7	48 0.	00 -27. 00 -27.	34		0.1 0.1		
33	325.59	-26.7	95 0.	00 -28.	21		0.1	18 -26.	.09[
	342.08 368.25			00 -28. 00 -28.		03 0.1	18 0.1 0.1		
3	396.53	-26.8	62 0.	00 -28	.62		0.1	18 -26	.46
	445.50 509.25			.00 -28 .00 -29			0.1 0.1	19 -27	.06
3	625.70	-27.6	09 0.	.00 -29 .00 -30	.94		0.1 0.1	19 -27	.66
	720.27 779.32	-29.4	45 0	.00 -30	.81		0.1	20 -28	.46
3			/51 Λ	.00] -31	4741		0.1	20 -28	.70
3	838.31 905.91			.00 -31		0.1	0.1	20 -29 20 -29	.11

Sur	nmary	table

Sample	x (ft)	d50 (mm)	Vf (ft/s)	A (ft^1/3)	Sample	x (ft)	d50 (mm)
Dune	-18.82	0.159	0.061	0.131	5	1533.42	
Midshore	47.5043	0.157	0.060	0.130	6	2110.61	
surf	115.013	0.183	0.071	0.140		2493.83	
1	257.625	0.163	0.062	0.132	8		
2	286.508	0.149	0.056	0.126	9		
3	404.038	0.135	0.051	0.121	10	3959.31	
4	706.822	0.139	0.052	0.122			5.754

					·		<u> </u>
Profile A							
Sample	Dune		retained	% retained		٥/	01
sieve #			(gms)	partial	Andal	% 	%
60	0.250	2.00	3.09		total 0.9	finer 99.1	coarser
80	0.180	2.47	103.08	5	30.8	69.2	0.9
100	0.150	2.74	94.3		58.1	41.9	30.8
120	0.125	3.00	101.75	29.5	87.6		58.1
140	0.106	3.24	34.49			12.4	87.6
170	0.090	3.47	7.23		97.6	2.4	97.6
200	0.075	3.74	1.06		99.7	0.3	99.7
200	0.075	Total	345.0	0.3	100.0	0.0	100.0
Phi 16 =	2.24	iotai	345.0	Ctd D			
Phi 50 =	2.65			Std Dev =	0.37		
Phi 84 =	2.97			Skew =	-0.08		
174	the milk half of the house			Vf (cm/s)=	1.86		
d50 (mm)	0.159			A (m^1/3)=	0.09		
M phi =	2.62	·- · · · · ·		Vf (ft/s) =	0.061		
dM (mm):	U.163 ((Folk-Ward)		A (ft^1/3) =	0.131		
C====!=	A Atalanta a san						
	Midshore			% retained			%
				partia!	total	finer .	coarser
60	0.250	2.00	2.1	0.5	0.5	99.5	0.5
80	0.180	2.47	133.5	33.3	33.9	66.1	33.9
100	0.150	2.74	80,9	20.2	54.1	45.9	54.1
120	0.125	3.00	125.4	31.3	85.4	14.6	85.4
140	0.106	3.24	47.8	11.9	97.3	2.7	97.3
170	0.090	3.47	9.7	2.4	99.7	0.3	99.7
200	0.075	3.74	1.1	0.3	100.0	-0.0	100.0
		207	400.5			0.0	100.0
Phi 16 = 🖁	2.23			Std dev =	0.38		
Phi 50 = 🖔	2.68			Skew =	-0.12		
Phi 84 = 🖁	2.99			Vf (cm/s)=	1.82		
d50 (mm)	0.157			A (m^1/3)=	0.09		
M phi =	2.63			Vf (ft/s) =			
dM (mm):		Folk-Ward)			0.060		
divi (min)	0.102 (1	OK-VVAIU)		A (ft^1/3) =	0.130		
Sample s	aurf	ne	tained 4	% retained			.,
							%
60	0.250	2.00	52.68				coarser
80	0.180		155.43	13.1	13.1	86.9	13.1
100	0.150	2.74	27.49	38.7	51.9	48.1	51.9
120	0.125	3.00	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	6.8	58.7	41.3	58.7
140	0.125	100	91.65	22.8	81.5	18.5	81.5
170	0.090	3.24	53.76	13.4	94.9	5.1	94.9
200		3.47	18.01	4.5	99.4	0.6	99.4
200	0.075	3.74		0.6	100.0	-0.0	100.0
Phi 16 = 📓	201		401.3				
Phi 50 =	2:04			Std dev =	0.50		
537	2,45			kew =	0.12		
Phi 84 = 🐇	3.04			/f (cm/s)=	2.16		
d50 (mm)	0.183			(m^1/3)=	0.09		
M phi =	2.51	-H-141 . IS		/f (ft/s) =	0.071		
dM (mm):	U.176 (F	olk-Ward)	P	(ft^1/3) =	0.140		
Sample 1					_		
•	(mm) Pi			6 retained	9		6
			ms) p				oarser
60	0.250	2.00	13,21	3.3	3.3	96.7	3.3
80	0.180		134.24	33.3	36.5	63.5	36.5
100	0.150	2.74	99.77	24.7	61.3	38.7	61.3
120	0.125		120.01	29.7	91.0	9.0	91.0
140	0.106	3.24	31.61	7.8	98.9	1.1	98.9
170	0.090	3.47	3,89	1.0	99.8	0.2	99.8
200	0.075	3.74	0.71	0.2	100.0	0.0	100.0
	name and a	mpE A S	403.4			-	. 50.0
Phi 16 = 🧓	2 18		_	td dev =	0.38		
Phi 50 = 🖔	2.62			kew =	-0.11		
Phi 84 =	2.94			f (cm/s)=	1.90		
d50 (mm)	0.163			(m^1/3)=	0.09		
M phi =	2.58			f (ft/s) =	0.062		
dM (mm):		olk-Ward)		(ft^1/3) =	0.132		
	(11	+ + • • • • • • • • • • • • • • • •	^	(11 110) -	0.102		

```
Sample 2
                                retained % retained
            d (mm) Phi
                                                     total
                                 (gms)
                                          partial
                                                              finer
                                                                       coarser
         60
                                   15.61
                0.250
                           2.00
                                                 3.9
                                                          3.9
                                                                  96.1
                                                                              3.9
         80
                0.180
                           2.47
                                   91.06
                                                22.6
                                                         26.4
                                                                  73.6
                                                                             26.4
        100
               0.150
                           274
                                   90.72
                                                22.5
                                                         48.9
                                                                  51.1
                                                                             48.9
        120
               0.125
                           3.00
                                   135.9
                                                33.7
                                                         82.6
                                                                  17.4
                                                                             82.6
        140
               0.106
                           3.24
                                   55.09
                                                13.7
                                                         96.3
                                                                   3.7
                                                                             96.3
        170
               0.090
                           3.47
                                   12,38
                                                 3.1
                                                         99.4
                                                                   0.6
                                                                             99.4
        200
               0.075
                           3.74
                                   2.57
                                                 0.6
                                                        100.0
                                                                   -0.0
                                                                            100.0
                                   403.3
   Phi 16 =
                2.25
                                         Std dev =
                                                         0.39
   Phi 50 =
                2.75
                                         Skew =
                                                        -0.19
   Phi 84 =
                3 03
                                         Vf (cm/s)=
                                                         1.72
   d50 (mm)
               0.149
                                         A (m^1/3)=
                                                        0.09
   M phi =
                2.68
                                         Vf (ft/s) =
                                                       0.056
   dM (mm):
               0.157 (Folk-Ward)
                                         A(\hat{t}^{1/3}) =
                                                       0.126
    Sample 3
                                retained % retained
                                                              96
   sieve # d (mm)
                    Phi
                               (gms)
                                        partial
                                                    total
                                                             finer
                                                                       coarser
        60
              0.250
                          2.00
                                  18.74
                                                4.6
                                                         4.6
                                                                  95.4
                                                                             4.6
        80
              0.180
                          2.47
                                  66.51
                                               16.5
                                                        21.1
                                                                  78.9
                                                                            21.1
       100
              0.150
                          2.74
                                   35.1
                                                87
                                                        29.8
                                                                  70.2
                                                                            29.8
       120
              0.125
                          3.00
                                 143.62
                                               35.5
                                                        65.3
                                                                  34.7
                                                                            65.3
       140
              0.106
                          3.24
                                  93.31
                                               23.1
                                                        88 4
                                                                  11.6
                                                                            88.4
       170
              0.090
                          3.47
                                  38.29
                                                95
                                                        97.9
                                                                  2.1
                                                                            97.9
       200
              0.075
                          3.74
                                  8.65
                                                2.1
                                                       100.0
                                                                           100.0
                                  404.2
  Phi 16 = 3
               2.33
                                        Std dev =
                                                        0.43
  Phi 50 = 🛞
               2.89
                                        Skew =
                                                       -0.19
  Phi 84 = 🦓
              3,19
                                        Vf (cm/s)=
                                                        1.55
  d50 (mm)
              0.135
                                        A (m^1/3) =
                                                        0.08
  M phi =
               2.80
                                        Vf (ft/s) =
                                                       0.051
  dM (mm):
              0.143 (Folk-Ward)
                                        A (ft^1/3) =
                                                      0.121
   Sample 4
                               retained % retained
                                                             %
  sieve # d (mm) Phi
                               (gms)
                                        partial
                                                   total
                                                            finer
                                                                      coarser
       60
              0.250
                         2.00
                                19.36
                                               4.8
                                                        4.8
                                                                95.2
                                                                            48
       80
              0.180
                                 82.81
                         2.47
                                              20.7
                                                        25.5
                                                                 74.5
                                                                            25.5
       100
              0.150
                         2.74
                                 34.24
                                               8.6
                                                       34.1
                                                                 65.9
                                                                            34.1
      120
              0.125
                         3.00
                                156 96
                                              39.2
                                                       73.3
                                                                 26.7
                                                                           73.3
      140
             0.106
                         3.24
                                 83.14
                                              20.8
                                                       94.1
                                                                  5.9
                                                                           94.1
      170
             0.090
                         3.47
                                 19.4
4.4
                                               4.8
                                                       98.9
                                                                  1.1
                                                                           98.9
      200
             0.075
                         3.74
                                                      100.0
                                                                 -0.0
                                                                          100.0
                                 400.3
 Phi 16 =
              225
                                       Std dev =
                                                       0.44
 Phi 50 =
              285
                                        Skew =
                                                       -0.25
 Phi 84 = 3.13
                                       Vf (cm/s)=
                                                       1.59
 d50 (mm)
             0.139
                                       A (m^1/3)=
                                                       0.08
 M phi =
              2.74
                                       Vf (ft/s) =
                                                      0.052
 dM (mm):
             0.150 (Folk-Ward)
                                       A (ft^1/3) =
                                                      0.122
  Sample 5
                              retained % retained
 sieve# d (mm)
                  Phi
                              (gms)
4.45
                                       partial
                                                  total
                                                           finer
                                                                     coarser
       60
             0.250
                         2.00
                                              1.0
                                                        1.0
                                                                99.0
                                                                            1.0
       80
             0.180
                                 17.05
                         2.47
                                               4.0
                                                        5.0
                                                                95.0
                                                                            50
      100
             0.150
                         2.74
                                25.92
                                              6.1
                                                       11.1
                                                                88.9
                                                                           11.1
      120
             0.125
                         3.00
                                131,91
                                             30.9
                                                       42.0
                                                                58.0
                                                                           42.0
     140
             0.106
                        3.24
                               179.97
                                             42.1
                                                      84.1
                                                                15.9
                                                                           84.1
     170
             0.090
                        3.47
                                52.9
                                             12.4
                                                      96.5
                                                                 3.5
                                                                          96.5
     200
             0.075
                        3.74
                                  15
                                              3.5
                                                      100.0
                                                                -0.0
                                                                         100.0
                                 427.2
Phi 16 =
              2.78
                                       Std dev =
                                                      0.23
Phi 50 =
              3.05
                                       Skew =
                                                      -0.14
Phi 84 =
            3.23
                                       Vf (cm/s)=
                                                      1.37
d50 (mm)
            0.121
                                       A (m^1/3)=
                                                      0.08
M phi =
             3.02
                                       Vf (ft/s) =
                                                     0.045
dM (mm):
            0.123 (Folk-Ward)
                                       A (ft^1/3) =
                                                     0.114
 Sample 6
                             retained % retained
                                                                    %
        d (mm) Phi
sieve#
                             (gms)
                                      partial
                                                  total
                                                           finer
                                                                    coarser
      60
            0.250
                                11.26
                        2.00
                                             2.8
                                                       2.8
                                                               97.2
                                                                           28
      80
            0.180
                        2.47
                                25.02
                                              6.2
                                                       9.0
                                                               91.0
                                                                           90
     100
            0.150
                        2.74
                                26.76
                                              6.6
                                                      15.6
                                                               84.4
                                                                          15.6
     120
            0.125
                        3.00
                               176.86
                                            43.8
                                                      59.5
                                                               40.5
                                                                          59.5
     140
            0.106
                        3.24
                               125.86
                                            31.2
                                                      90.6
                                                                9.4
                                                                          90.6
     170
            0.090
                        3.47
                                34.93
                                             8.7
                                                      99.3
                                                                0.7
                                                                          993
     200
            0.075
                        3.74
                                2.8
                                             0.7
                                                     100.0
                                                                0.0
                                                                         100.0
                                403.5
Phi 16 = Phi 50 =
                                      Std dev =
                                                      0.22
            2.94
                                      Skew =
                                                      0.07
Phi 84 =
            3.19
                                      Vf (cm/s)=
                                                      1.49
d50 (mm)
           0.130
                                      A (m^1/3)=
                                                     0.08
M phi =
             2.96
                                      Vf (ft/s) =
                                                    0.049
dM (mm):
           0.129 (Folk-Ward)
                                      A (\hat{t}^4)/3) =
                                                    0.119
```

```
Sample 7
                            retained % retained
                                                        %
                                                                %
  sieve # d (mm) Phi
                            (gms) partial total finer
9.12 2.2 2.2 9
                                                               coarser
       60
             0.250
                       2.00
                                           2.2
                                                   2.2
                                                           97.8
                                                                      2.2
       80
             0.180
                       2.47
                               34.61
                                           8.4
                                                   10.6
                                                           89.4
                                                                     10.6
      100
             0.150
                       2.74 26.86
                                           6.5
                                                   17.2
                                                           82.8
                                                                     17.2
      120
             0.125
                       3.00
                              147.66
                                          35.9
                                                   53.1
                                                           46.9
                                                                     53.1
      140
                       3.24
             0.106
                              145.15
                                          35.3
                                                   88.4
                                                           11.6
                                                                     88.4
                       3.47 41.56
      170
            0.090
                                          10.1
                                                   98.5
                                                            1.5
                                                                     98.5
      200
            0.075
                       3.74 5.96
                                           1.5
                                                  100.0
                                                            0.0
                                                                    100.0
                               410.9
  Phi 16 = 9
             2.70
                                     Std dev =
                                                  0.25
  Phi 50 =
             2.98
                                    Skew =
                                                  -0.05
  Phi 84 = 3.21
                                    Vf (cm/s)=
                                                  1.45
 d50 (mm 0.127
                                    A (m^1/3) =
                                                  0.08
 M phi =
             2.96
                                    Vf(ft/s) =
                                                 0.048
 dM (mm) 0.128 (Folk-Ward)
                                    A(ft^1/3) =
                                                 0.117
  Sample 8
                            retained % retained
                            (gms) partial 2.8
 sieve # d (mm) Phi
                                              total
                                                       finer
                                                               coarser
      60
            0.250
                       2.00
                                        2.8
                                                  2.8
                                                          97.2
      80
            0.180
                       2.47
                              38.94
                                           9.5
                                                  12.3
                                                          87.7
                                                                     12.3
     100
            0.150
                       2.74 27.66
                                           6.7
                                                  19.1
                                                           80.9
                                                                    19.1
     120
                      3.00 186.06
            0.125
                                          45.4
                                                  64.4
                                                           35.6
                                                                    64.4
     140
            0.106
                      3.24 113.47
                                                  92.1
                                         27.7
                                                           7.9
                                                                    92.1
                      3.47 20.44
3.74 11.99
     170
            0.090
                                          5.0
                                                  97.1
                                                           2.9
                                                                    97.1
     200
            0.075
                                          2.9
                                                 100.0
                                                           0.0
                                                                   100.0
                              410.2
 Phi 16 = 2.63
                                    Std dev =
                                                  0.27
 Phi 50 =
             2.92
                                    Skew =
                                                 -0.06
 Phi 84 = 3.17
                                    Vf (cm/s)=
                                                 1.51
 d50 (mm 0.132
                                    A (m^1/3) =
                                                  0.08
M phi =
            2.91
                                   Vf(ft/s) =
                                                 0.050
dM (mm) 0.134 (Folk-Ward)
                                   A (ft^1/3) =
                                                0.119
 Sample 9
                           retained % retained
                                                      %
                                                               %
sieve # d (mm) Phi
                      (gms) partial total 2.00 19.95 5.1 5.1
                                                      finer
                                                               coarser
     60
           0.250
                                                 5.1
                                                          94.9
                                                                    5.1
     80
           0.180
                      2.47
                             32.55
                                          8.3
                                                          86.7
                                                 13.3
                                                                    13.3
    100
           0.150
                      2.74
                             31.46
                                          8.0
                                                 21.3
                                                          78.7
                                                                    21.3
                      3.00 139.37
3.24 121.81
    120
           0.125
                                         35.4
                                                 56.7
                                                          43.3
                                                                    56.7
    140
           0.106
                                         30.9
                                                 87.7
                                                          12.3
                                                                    87.7
                      3.47 40.34
    170
           0.090
                                         10.2
                                                 97.9
                                                           2.1
                                                                    97.9
    200
           0.075
                      3.74 8.2
                                                100.0
                                                          -0.0
                                                                   100.0
                             393.7
Phi 16 = 🎥
            2.56
                                   Std dev =
                                                 0.33
Phi 50 =
            2.95
                                   Skew =
                                                 -0.13
Phi 84 = 3.21
                                   Vf (cm/s)=
                                                 1.48
d50 (mm 0.129
                                   A (m^1/3) =
                                                 0.08
M phi =
           2.91
                                   Vf (ft/s) =
                                                0.048
         0.133 (Folk-Ward)
dM (mm)
                                   A (ft^1/3) =
                                                0.118
Sample 10
                          retained % retained
                                                      %
                                                              %
sieve # d (mm) Phi
                                   partial total
                          (gms)
                                                      finer
                                                              coarser
    60
          0.250
                     2.00 20.89
                                      5.2
                                                 5.2
                                                         94.8
                                                                   5.2
     80
          0.180
                     2.47
                           37.43
                                         9.2
                                                         85.6
                                                 14.4
                                                                   14.4
    100
          0.150
                     2.74
                            37,63
                                         9.3
                                                 23.7
                                                         76.3
                                                                   23.7
    120
          0.125
                     3.00
                            168.39
                                        41.6
                                                 65.3
                                                         34.7
                                                                   65.3
    140
          0.106
                     3.24
                            106.39
                                                          8.5
                                        26.3
                                                 91.5
                                                                   91.5
                     3.47 28.15
    170
          0.090
                                         7.0
                                                 98.5
                                                          1.5
                                                                   98.5
    200
          0.075
                     3.74 6.09
                                         1.5
                                                100.0
                                                          0.0
                                                                  100.0
                             405.0
Phi 16 = 2.53
                                   Std dev =
Phi 50 =
           2.90
                                   Skew =
                                                -0.10
Phi 84 = 3.18
                                  Vf (cm/s)=
                                                1.53
d50 (mm
          0.134
                                  A (m^1/3) =
                                                0.08
M phi =
           2.87
                                  Vf(ft/s) =
                                               0.050
dM (mm) 0.137 (Folk-Ward)
                                  A (ft^1/3) =
                                               0.120
```

Sakari Destila A					
Actual Profile A x (ft)			ew x (ft)	new z (ft)	Area (ft^2
-18.8	0 4.31231 -0	0.6151025			
15.274 23.917	3 2.41596 -0	0.0547604	150	-1.0789887	
35,787	1 1.70484 -0	0.0164689	200	-2.4135635	-87.3138 -130.89
47.504 62.077		0.0188843		-2.8220377 -4.8508534	-191.822
79.560	1 0.92652 -0	0.0298395	350	-4.1090877	
97.657 115.01		0.0221903		-6.1558913 -8.5910408	
136.48	6 -0.39144 -	0.0508754	500	-7.9843899 -6.108694	
154.43		0.0252092 0.0178491	550 600	-6.8612625	-324.249
189.18	6 -2.04605 -	0.0339854	650	-8.6689766 10.363544	
		0.0037464	700 750	-10.363544 -11.339799	-542.584
243.23	6 -2.46725 -	0.0524528		-11.507181 -11.047242	
257.62 267.08		0.0663231	900	-10.47543	-538.067
279.38	39 -4.61551 -	0.0240967	950 1000	-10.455185	-523.265 -522.253
293.26 308.0		0.0146909	1050	-10.414696	-521.241
312.20		0.0037382 0.0405358	1100	-10.731273 -11.274693	-528.649 -550.149
329.3 345.4		0.0253957		-11.818114	-577.32
		-0.0517051 -0.0053357	1250	-12.30591 -12.694985	
	08 -4.84013 -	-0.0090155	1350	-13.030234	-643.13
291.3	01 -4.88334	0.0047952	1400 1450	-13.208417 -13.3866	
302. 313.4	96 -4.82743 48 -4.76153	0.0097965	1500	-13.564783	673.785
		0.0118769	1550 1600		-683.032 -692.7
404.0	27 -5.65183 38 -6.40193	-0.0568382	1650	-13.98289	698.359
413.	89 -6.96188			-14.16566 -14.56206	
458.1 481.6	98 -8.9609 64 -8.59582	0.0153076	1800	-14.84960	2 -735.292
488.0	55 -8.49798 59 -6.07704	0.0429979	1850		
	41 -6.28793	-0.024536	1950	-15.79523	4 -780.697
584.4 594.8		-0.0317424 -0.0353206	2000	-16.15869 -16.36291	3 -798.848 3 -813.04
	95 -7.39795	-0.0373173	2100	-16.99560	3 -833.963
638.1 693		-0.0349725 -0.0269997		-17.39735 -17.22044	
706.8	22 -10.5477	-0.0216624	225	-18.1825	7 -885.075
710.2 716.9		-0.0419929 -0.01251) -18.58966) -18.93075	2 -919.306 1 -938.01
728.7	777 -11.0512	-0.0078564	240	-19.50736	1 -960.953
		-0.0161322 -0.0083175			3 -987.884 9 -1009.9
765.3	361 -11.4676	-0.0051774	255	20.88287	6 -1031.77
790.3 854		0.0091988			
861.9	989 -10.8829	0.0139803	270	0 -22.18395	3 -1098.71
	334 -10.7103 2.17 -10.4786	0.0004049			8 -1119.69 6 -1140.67
1070	.12 -10.4065	-0.0108684			2 -1160.29
1231 1312	.98 -12.1657 2.15 -12.7896	-0.0077815 -0.0098486		0 -24.2524	6 -1199.9
1328	1.99 -12.9554 1.42 -13.6839	-0.003563 0.17822			78 -1225.8° 34 -1247.14
	1.08 -13.5664		310	0 -25.431	9 -1263.42
1547	7.52 -13.744 0.55 -13.9106	-0.005043 -0.002103		0 -25.6503 0 -25.921	
1628	3.58 -14.0116	0.001340	325	0 -26.3405	35 -1306.5
	5.38 -13.9489 5.14 -14.4751			0 -26.649	38 -1324.7 95 -1336.
1793	3.73 -14.8179	-0.005047	340	0 -26.8615	41 -1341.9
10	5.84 -15.1365 22.3 -15.5856	_0.007565	350	0 -26.8458 0 -26.7694	65 -1340.3
199	5.07 -16.1438	-0.003790	355	0 -27.054	01 -1345.5
204	8.35 -16.342 8.89 -16.9818	-0.012658 -0.0124	4 365	0 -27.9338	85 -1383.8
211	0.61 -17.1276	-0.006530	8 370	0 -28.6026 0 -29.1613	28 -1413.4
215	3.16 -17.2749 4.79 -17.4322	0.004684	1] 380	0 -29.4554	67]-1465.4
220	1.44 -17.2137	-0.019954	4 38	0 -29.4481	58 -1472.5
23	1.57 -18.4135 33.9 -18.7451	-0.011532	2 39	0 -29.8950	29 -1480.7
241	8.32 -19.7187	-0.009134	3	Total Are	a -66110
249	6.67 -20.2516 3.83 -20.3224	-0.010611	1		
252	5.59 -20.6594 5.45 -21.3904 8.96 -23.2663 6.67 -23.5435	-0.009153	5		
282	8.96 -23.266	-0.005810	6		
287	6.87 -23.5435 6.54 -23.9716	-0.008584	91		
	6.54 -23.9716 2987 -24.6954	-0.006511	1		
312	9.55 -25.6236 9.89 -25.4716	0.447312	2		
1 314	0.051-25.6173	31-0.003323	184		
226	79.3 -25.747 8.84 -26.414	7 _0 005701	21		
332	5.59 -26.7953	3 0.000217	8		
	2.08 -26.791 8.25 -26.867				
339	6.53 -26.862	2 0.000193	<u>4</u>		
	145.5 -26.852 19.25 -26.755				
36	25.7 -27.608	9 -0.013374	19		
377	20.27 -28.873 79.32 -29.444	9 -0.00050	38		
383	38.31 -29.47	5 0.00229 2 -0.01304	21]		
	59.31 -30.016		Ï		
			 В-7		

	Predicted		DOW Y (8)	DOM 7 /#\	Area (ft^2)
x (ft) 115.01344	z (ft) 0	-0.04663	new x (ft)	new z (II)	Alea (IL 2)
136.4856	-1.00126	-0.02786			
154.43112 170.90886	-1.501149 -1.894729	-0.02389 -0.02152	150	-1.37771583	
189.18605	-2.288014	-0.01987	200	-2.50284007	-97.0139
205.77813	-2.617626	-0.0186	250 300	-3.40947137 -4,20707791	-147.8078 -190.4137
243,23604	-2.977011 -3.295637	-0.01757 -0.01683	350	-4.93473849	-228.5454
257.62488	-3.537794	-0.01636	400	-5.61253782	-263.6819
267.08176	-3.692514 -3.889146	-0.01598 -0.01556	450 500	-6.24955219 -6.85635874	-296.5523 -327.6478
279.38882 293.26295	-4.10502	-0.01515	550	-7.43992919	-357.4072
308.01079	-4.328432	-0.0149	600	-8.00019086	-386.003 -413.4963
312.28336 329.3732	-4.39208 -4.642214	-0.01464 -0.01426	650 700	-8.53966095 -9.06540232	-440.1266
345.46221	-4.871686	-0.0139	750	-9.57491086	-466.0078
365.66886	-5.152457		800 850	-10.0700476 -10.5550045	-491,124 -515.6263
381.96188 286.50797	-5.373385 -4.000644		900	-11.0266102	
291.30107	-4.074843	-0.01524	950	-11.4801908	
302.95966 313.44796	-4.252576 -4.409349		1000 1050	-11.9337713 -12.3873518	
315.26648			1100	-12.8251383	-630.3123
391.72661	-5.503634				
404.03829 413.88998	-5.665694 -5.793721				
458.19776	-6.353036	-0.0122	1300	-14.5125235	-715.3373
481.66353 488.05549					
544.35914			•		
581.94102	-7.800624	-0.01113	1500	-16.0981525	-795.0478
584.46724					
594.88515 615.19483				-17.2459958	-852.8845
638.13869	-8.4146	-0.01054	1700	-17,6182797	-871.6069
693.21994 706.82229					
710.24495	-9.171076	-0.01025	1850	-18.7134633	926.6414
716.94349					
728.77658					
747.45958	-9.549458	-0.01002	2050		997.5695
765.36127 790.2808					
854.3799					4 -1049.143
861.98895	-10.67007	-0.0095			
874.33424 892.16987					
1070.122			1 2400	-22.484029	5 -1115.972
1231.9807					
1312.1534 1328.9881					
1533.4223	-16.36178	3 -0.00769	2600	-23.77802	8 -1180.89
1534.0815 1547.5186					
1580.5452					
1628.5824	-17.0856	4 -0.0074			
1675.3816 1735.1383					
1793.7289	-18,3068	3 -0.0072	3 2950	-25.961223	1 -1290.409
1856.844					
1922.298				26,868264	
2048.345	3 -20.114	1 -0.0069	1 3150	27.168521	5 -1350.92
2098.8929	9 -20.4631 9 -20.5436	9 -0.0068		27.465808 -27.761975	6 -1365,858 9 -1380,695
2133.164	6 -20.6981	8 -0.0068	3 3300	28.056256	7 -1395.456
2154.791	-20.8457	9 -0.0067	9 3350	28.349408	5 -1410.142
2201.444		4 -0.0067 8 -0.0066		0 -28.640771 0 -28.930632	
2333.901	5 -22.0488	8 -0.0065	350	29.219010	8 -1453,741
2418.323 2476.671		6 -0.0065 1 -0.0064		0 -29.505330 0 -29.791182	
2493.825		8 -0.0064			
2525.589	7 -23.3011	3 -0.0064	1 370	30.35864	2 -1510.857
2605.448 2828.960		5 -0.0062 3 -0.0061		30.640442 30.920806	8 -1524.977 2 -1539.031
2876.671	8 -25.5119	1 -0.0061	4 385	31.199918	5 -1553.018
2926.542				31.477821	
2987.00 3129.549		4 -0.0060 3 -0.0059		731.75442 Total Area	3 -1580.806 -73026.76
3129.889	5 -27.0484	7 -0.0059	8		
3140.047 3179.304		9 -0.0059 2 -0.0059			
3258.840		4 -0.0058			
3325.594	7 -28.2066	9 -0.0058	5		
3342.083 3368.250		8 -0.0058 8 -0.0058			
	4 -28.6206	3 -0.005	8		
3445.501		8 -0.0057			
3509.252 3625.704	9 -29.2723 6 -29.9381	8 -0.0057 4 -0.0056			
3720.274	6 -30.4733	9 -0.0056	2		
3779.315		9 -0.0055			
3838.308 3905.913		3 -0.0055 9 -0.0055			
3959.309]		

115 013	Profile A	Predicted	1			
136.466 1.079764 0.029698 154.431 1.612703 0.02524 170.909 2.028602 0.022556 150 1.4811092 170.909 2.028602 0.022556 150 1.4811092 150.1816 2.440558 0.020633 200 2.6633766 103.6272 205.776 2.763198 0.019162 220 3.5934094 156.6347 225.628 3.476397 0.017016 300 4.3731503 199.164 242.236 3.476397 0.017016 350 5.0150629 234.7276 276.7062 3.676193 0.016404 400 5.8322437 277.0052 277.389 4.071484 0.014803 500 5.894557 333.4477 279.389 4.071484 0.014803 500 5.9404557 333.4477 279.389 4.071484 0.014803 500 7.9748842 380.1631 308.011 4.485594 0.013402 500 7.9748842 380.1631 308.011 4.485594 0.013402 500 7.9748842 380.1631 308.011 4.485594 0.013402 500 7.9748842 380.1631 383.373 4.766615 0.012256 700 8.9497755 435.434 435.442 4963985 0.011518 750 9.4189241 459.2175 365.669 5.196442 0.010718 800 9.873401 482.3061 381.962 5.371068 0.010703 850 1.037781 594.7795 3013 4.47986 0.01403 900 10.746968 526.6187 302.86 508 4.349412 0.01403 900 10.746968 526.6187 504.7795 3013 4.479645 0.013551 1000 11.57181 568.28 302.98 4.662169 0.013756 1000 11.57181 568.28 303.98 4.672445 0.013551 1000 11.57289 547.6589 303.7848 579.5485 0.011487 1200 3.341661 647.5496 475.0885 5.075445 0.010797 350 1.482983 7.02866 6.909.029 315.266 4.75368 0.011487 1200 3.341661 647.5496 4.754645 0.010797 350 1.4529869 6.090.629 3013 4.4772856 0.000864 1.00066 1.92627 1.76464 1.000868 5.90066			coefficient n	ew x (ft)	new z (ft)	Area (ft^2)
154.431 .612703 .0.02524						
170 909						
189.186 2.440958 0.020933 200 2.6639796 103.9272 275.798 3.153406 0.017916 300 4.3731503 199.184 243.236 3.476397 0.017004 350 5.0159629 234.7276 243.236 3.476397 0.017004 350 5.0159629 234.7276 243.236 3.476397 0.017004 350 5.0159629 234.7276 257.625 3.723061 0.016404 400 5.8522437 271.2052 287.082 3.878193 0.015706 450 6.3974495 305.7423 287.082 3.878193 0.015706 450 6.3974495 305.7423 287.082 3.478249 0.014093 500 6.9404587 333.4477 283.263 4.278249 0.014093 500 6.9404587 333.4477 283.263 4.278249 0.014093 500 6.9404587 333.4477 283.263 4.585944 0.013004 650 8.4675848 411.9567 283.373 4.685944 0.013004 650 8.4675848 411.9567 285.566 5.196422 0.017018 800 8.4987755 455.434 345.462 4.963895 0.011518 750 9.4189241 459.2175 286.566 4.349412 0.014007 900 0.873401 482.3081 381.962 5.371088 0.010703 850 10.317781 504.7795 286.506 4.349412 0.014007 900 10.746988 526.6167 291.301 4.47968 0.014053 930 11.159339 547.6589 302.06 4.582169 0.013756 1000 11.57181 568.281 315.266 4.751088 0.012874 1100 12.376286 609.0628 315.266 4.751088 0.012874 1100 12.376286 609.0628 316.266 4.751088 0.011487 1200 13.141661 647.5409 317.276.75459 0.01159 1050 11.984231 568.265 318.48 4.76245 0.01551 1050 11.984231 568.265 319.31 4.7795459 0.011708 100 12.759974 528.4565 319.31 4.7795459 0.011708 100 13.75658 684.4438 316.266 4.751088 0.010874 1400 14.57658 684.4438 316.266 4.751088 0.001087 1400 14.57658 684.4438 316.866 5.76469 0.001097 1300 13.516096 666.4439 317.976 5.46459 0.00308 1450 14.916165 737.7128 318.40 4.76589 0.000808 1450 14.916165 737.7128 318.40 4.76589 0.000808 14.500 14.52566 4.720.0385 318.40 4.76589 0.000808 14.500 14.5256				450	4 4044000	
206 776 2.763198 0.019162 250 3.5934094 166.4947 225 698 3.163406 0.017918 300 4.3731503 199.164 243 226 3.476597 0.017094 350 5.0159629 234.7276 257 625 3.723061 0.016401 400 5.8322437 271.2052 257 625 3.723061 0.016401 400 5.8322437 271.2052 257 626 3.7676193 0.015706 450 4.391405 305.4733 279 389 4.071484 0.014905 500 6.9404567 333.4477 330 6.011 4.485594 0.013402 500 7.78748842 380.1631 308 0.011 4.485594 0.013402 500 7.78748842 380.1631 308 0.011 4.485594 0.013402 500 7.78748842 380.1631 308 0.011 4.485594 0.013402 500 7.8748842 380.1631 308 0.013 4.786615 0.012256 700 8.9497755 435.434 435 4.622 4963969 0.0171518 750 9.4189241 459.2175 365.669 5.196442 0.010718 800 9.873401 482.3081 319.602 5.371068 0.010703 880 0.317761 504.7795 381.902 5.371068 0.012074 100 1.014086 526.6187 302.96 4.62199 0.013756 1000 -11,57181 568.23 302.96 4.62199 0.013756 1000 -11,57181 568.23 303.96 4.675108 0.012874 1100 12.376286 609.0623 313.448 4.726445 0.013551 1050 11,984231 588.901 315.266 4.75108 0.012874 1100 12.276286 609.0623 319.727 5.735459 0.011698 1150 12.759974 628.6454 401.684 6.74546 0.010551 1250 13.516096 666.4433 401.684 6.74546 0.01051 1400 1.377615 666.4433 401.684 6.74546 0.01054 1400 1.4572564 7.70.0382 401.680 5.986377 0.00064 1.550 1.529767 7.71.4373 401.680 5.986377 0.00064 1.550 1.529767 7.71.4373 401.680 5.986370 0.00094 1.000 1.529676 7.72.00382 401.680 5.886371 0.008644 200 1.98879 9.46633 3.000347 401.680 5.000647 200094 1.00094 1.00094 1.00094 1.00094 401.680 5.00064 5.00064 1.00064 1.00064 1.00064 1.00064 1.00064 1.00064 1.00064 1.00064 1.00064 1.00064 1.00064 1.00064 1.00064 1.00064 1.00064 1.00064 1.						103 6272
225.088 3.153-406 .0-017916 .300 4.3731503 .199.164 243.286 3.476397 .0-017004 .300 5.0150673 .304 7278 257.625 3.773061 .0-016404 .400 5.832437 .271.0052 257.625 3.773061 .0-016404 .400 5.832437 .271.0052 257.026 3.876193 .0-01706 .450 6.3974485 .305.7423 279.3061 .0-01494 .0-014903 .500 6.3949575 .333.4477 283.263 4.276249 .0-014086 .550 7.4660683 .360.1631 312.283 4.543255 .0-013064 .550 .7.4660683 .360.1631 312.283 4.543255 .0-013064 .550 .8.467548 .411.0567 345.56 4.963695 .0-011518 .750 .9.489241 .459.2175 356.669 5.166452 .0-017018 .800 .873401 .482.3081 381.962 5.371089 .0-010703 .850 .0-317781 .504.7958 302.86 4.582169 .0-013075 .900 .00746986 .266.8187 302.86 4.582169 .0-013075 .900 .01746986 .266.8187 313.448 .7756455 .0-0130551 .050 .11,57181 .568.28 313.448 .7756455 .0-0130551 .050 .11,57181 .568.28 315.266 .751088 .0-012674 .100 .12,376266 .690.0523 317.27 .7575459 .0-01168 .150 .12,769974 .268.4556 404.038 5.879485 .0-011487 .100 .12,769974 .268.4556 404.038 5.879485 .0-01197 .150 .13,11661 .467.5409 404.038 5.879485 .0-01197 .150 .13,11661 .467.5409 405.86 .752356 .0-00097 .1000 .13,17656 .684.439 .0-01097 .150 .13,161096 .664.439 404.038 5.879485 .0-01197 .150 .13,161096 .664.439 .150 .14,1661 .467.5409 .0000 .15,1661 .475.6409 .0000 .15,1661 .475.6409 .0000 .15,1661 .475.6409 .0000 .15,1661 .475.6409 .0000 .15,1661 .475.6409 .0000 .15,1661 .475.6409 .0000 .15,1661 .475.6409 .0000 .15,1661 .475.6409 .0000 .15,1661 .475.6409 .0000 .15,1661 .475.6409 .0000 .15,1661 .475.6409 .0000 .15,1661 .475.6409 .0000 .15,1661 .475.6409 .0000 .15,1661 .475.6409 .0000 .15,1661 .475.6409 .0000 .15,1661 .15,1661 .475.6409 .0000						
294 276 3 476397 .0.017004 350 5.0159629 234.7276 277.6252 3.676393 3.015706 450 6.3327437 277.0352 267.082 3.676393 3.015706 450 6.3327437 277.0352 267.082 3.676393 3.015706 450 6.3974495 305.7423 306.011 4.485994 .0.013402 500 7.9748842 380.01631 308.011 4.485994 .0.013402 500 7.9748842 380.01631 308.011 4.485994 .0.013402 500 7.9748842 380.01631 308.011 4.485994 .0.013402 500 8.949755 435.434 435.462 4863895 .0.01516 750 9.498241 459.2175 365.669 5.196442 .0.010718 800 9.673401 482.3081 365.669 5.196442 .0.010703 80 9.673401 482.3081 391.962 5.371068 .0.014083 960 0.317781 504.7785 302.861 4.562169 .0.013756 10.00 -11.57181 568.28 313.448 4.726445 .0.01355 10.00 -11.57181 568.28 313.448 4.726445 .0.01355 10.00 -11.57281 568.29 315.266 4.751088 .0.012741 11.00 -12.376286 609.0623 391.727 5.735459 .0.011698 1150 12.376286 609.0623 391.727 5.735459 .0.011698 1150 12.376286 609.0623 391.727 5.735459 .0.011698 1150 12.376286 609.0623 488.055 6.814476 .0.010547 4100 4.672646 4.675.649 3.010547 4100 4.672646 4.675.649 3.010547 4100 4.672646 4.675.649 3.010547 4100 4.672646 4.675.649 3.010547 4100 4.672646 4.675.649 3.010547 4100 4.672646 4.675.649 3.010547 4100 4.672646 4.675.649 3.010547 4100 4.672646 4.675.649 3.010547 4100 4.672646 4.675.649 3.010547 4100 4.672646 4.675.649 3.010547 4100 4.672646 4.675.649 3.010547 4100 4.672646 4.675.649 3.010547 4100 4.672646 4.675.649 4.675.6						
287 287						
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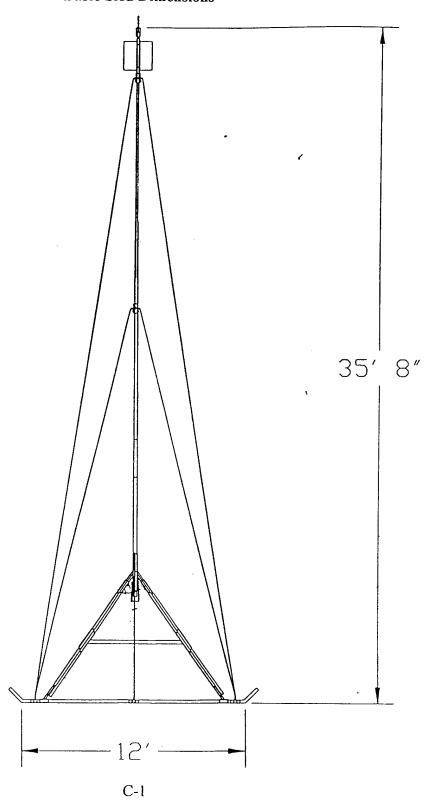
RMS of the distance [(zpred-zmeas)^2]^.5

	(zpred-zme	
x (ft)	Method 1:	Method 2:
	z error (ft)	z error (ft)
150 200	0.299	0.402
	0.089	0.250
250	0.587	0.771
300	0.644	0.478
350	0.826	0.907
400	0.543	0.324
450	2.341	2.194
500	1.128	1.044
550	1.331	1.357
600	1.139	1.113
650	0.129	0.201
700	1.298	1.414
750	1.765	1.921
800	1.437	1.634
850	0.492	0.729
900	0.551	0.272
950	1.025	0.704
1000	1.499	1.137
1050	1.973	1.570
1100	2.094	1.647
1150	1.978	1.485
1200	1.861	
1250	1.795	1.324
1300	1.818	1.210
1350		1.183
	1.885	1.199
1400	2.101	1.364
1450	2.317	1.530
1500	2.533	1.695
1550	2.732	1.841
1600	2.918	1.971
1650	3.263	2.263
1700	3.453	2.402
1750	3.425	2.325
1800	3.503	2.356
1850	3.611	2,421
1900	3.638	2.406
1950	3.630	2.357
2000	3,619	2.307
2050	3.763	2.415
2100	3,475	2.093
2150	3.416	2.002
2200	3.932	2.486
2250	3.307	1.828
2300	3.233	1.721
2350	3.224	1.679
2400	2.977	1.398
2450	2.803	1.190
2500	2.748	
2550	2.575	1.101
2600	2.437	0.893 0.722
2650	2.329	
2700	2.329	0.582 0.445
2750	2.223	
2800		0.308
2850	2.012	0.171
2900	1.959	0.089
2950	1.911	0.016
	1.709	0.212
3000	1.485	0.461
3050	1.461	0.510
3100	1.437	0.560
3150	1.518	0.504
3200	1.545	0.505
3250	1.421	0.654
3300	1.407	0.696
3350	1.535	0.595
3400	1.779	0.378
3450	2.085	0.099
3500	2.450	0.239
3550	2.451	0.216
3600	2.371	0.110
3650	2.142	0.143
3700	1.756	0.553
3750	1.479	0.853
3800	1.465	0.889
3850	1.752	0.624
3900	2.144	0.252
3950	1.859	0.557
Total	158.96	84.46
- west	.50.00	UT.TU
Average	2.06	1.10
	2.00	1.10

APPENDIX

 \mathbf{C}

Basic Sled Dimensions



Equipment Needed

- 1. Ten foot ladder
- 2. To tighten all bolts3/4" wrench3/4" socket and rachet
- 3. To tighten cables 5/16" socket and rachet
- 4. Hammer

All Parts are located above room 117 B in the hydrolab:

Pole A

Pole B

Pole C

Yoke

Skids 1 & 2

Leg 1A

Leg 2A

Leg 1B

Leg 2B

Red brace

White brace

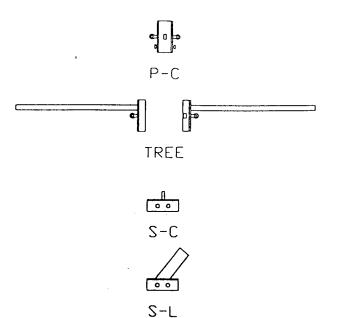
GPS box

Triple prism connector

Sled Locker is located outside room 117B near the door.

Weights of Sled Pieces

Poles:	
Α	9.5 lb.
В	10.5 lb.
С	29.0 lb.
Braces:	
Front Brace (red)	24.0 lb.
Back Brace (white)	24.0 lb.
Back Plates	3.5 lb.
Legs:	
1 A	43.0 lb.
1B	43.5 lb.
2A	43.0 lb.
2B	43.0 lb.
Skids:	
1	35.75 lb.
2	35.75 lb.
Others:	•
GPS Box	28.0 lb.
Yoke	22.5 lb.
Tree	5.5 lb.
Cable Connection:	
To Skids	3.5 lb.
To Pole	3.0 lb.
GPS Antenna	2.5 lb.
Triple Prism	4.0 lb.

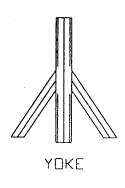


Pole to Cable Connector (P-C): P-C is bolted to Pole A & Cable connects to loops

Tree: Cables are connected to tree located in the middle of pole B. Side Cables run through arms to stop cable from swaying

Skid to cable connectors (S-C): S-C is bolted to skid & cable is connected to loop on top of S-C.

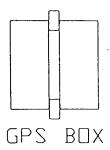
Skid to leg connector (S-L): S-L is bolted to the skid & then the legs bolt to S-L



Yoke: the legs connect to the yoke & pole C is bolted to the sleeve on top of the yoke



GPS antenna connector (GPS A): GPS antenna is screwed onto the threaded shaft & connector is pinned to pole A



GPS Box: the GPS battery & Data Processor are placed inside the box. The box is pinned onto pole A POLE A

Pole A is 14 ft long with 1.25" outer diameter. The top has 5 pairs of holes in it.

POLE B

Pole B is 12 ft long and has a outer diameter of 1.75"

POLE C

Pole C is 11 ft long and has a diameter of 2.25"

LEG

There are 4 legs labeled 1A, 2A, 1B, 2B

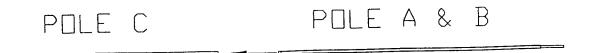
SKID

There are two skids marked 1 & 2

Steps for assembly



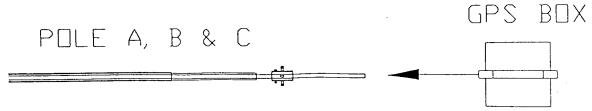
1. Insert Pole A into Pole B



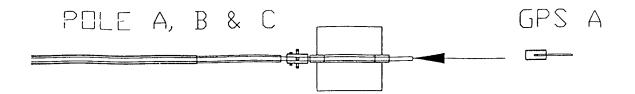
2. Insert Poles A&B into Pole C



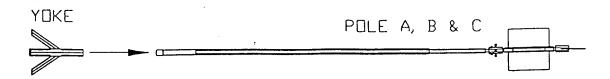
3. Bolt P-C to Pole A with the 3" bolts (purple paint) at the 4th and 5th hole from the top of Pole A



4. Bolt the GPS Box to the 2nd and 3rd holes from the top of Pole A with the stainless steel pins and cotter pins



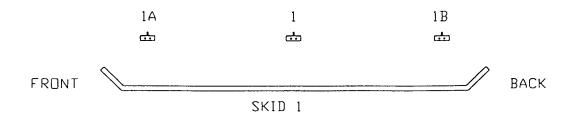
5. Attach GPS A to the first hole from the top of Pole A with stainless steel pin and cotter pins



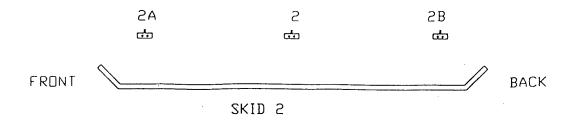
6. Insert Poles A, B, and C into the yoke

Skids:

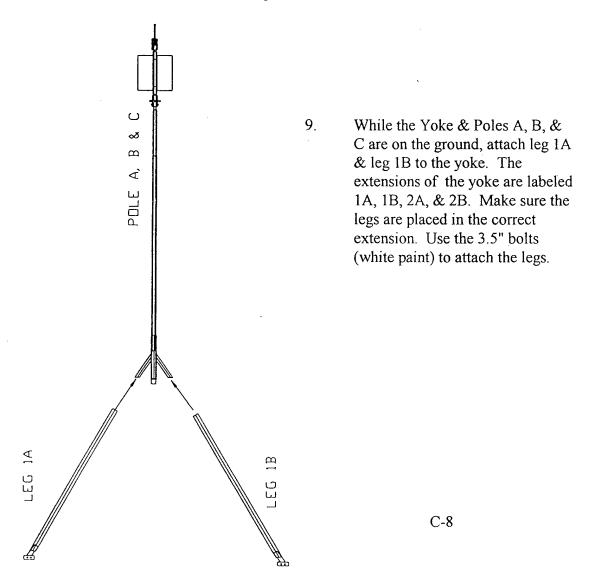
The skids are labeled 1 & 2. With skid #1 on the left and #2 on the right

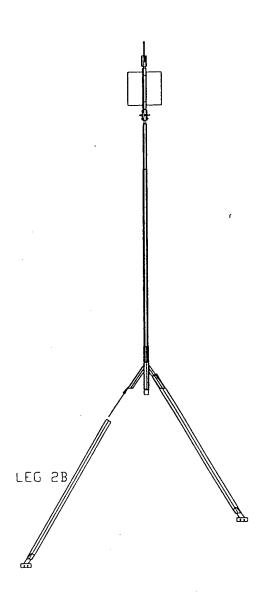


7. Attach S-C 1A, S-C 1, & S-C 1-B to skid 1 with the 6" bolts (Bronze paint). S-C 1A should be placed at the front of the skid, while S-C 1B should be placed at the center of skid 1. S-C 1 should be placed at the center of skid 1.

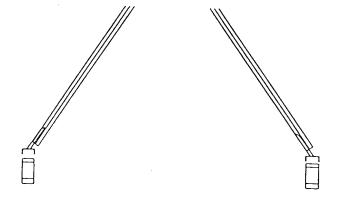


8. Attach S-C 2A, S-c 2, & S-C 2B to skid 2 with 6" bolts. S-C 2A should be placed at the front of the skid, while S-C 2B should be placed at the center of skid 2. S-C 2 should be placed at the center of skid 2.

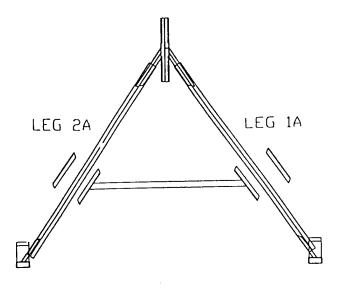




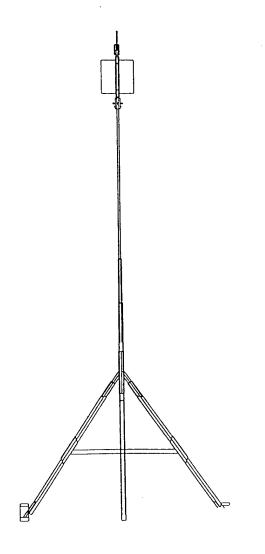
10. Raise the yoke up & attach leg 2A & leg 2B with the 3.5" bolts (white paint) to the yoke.



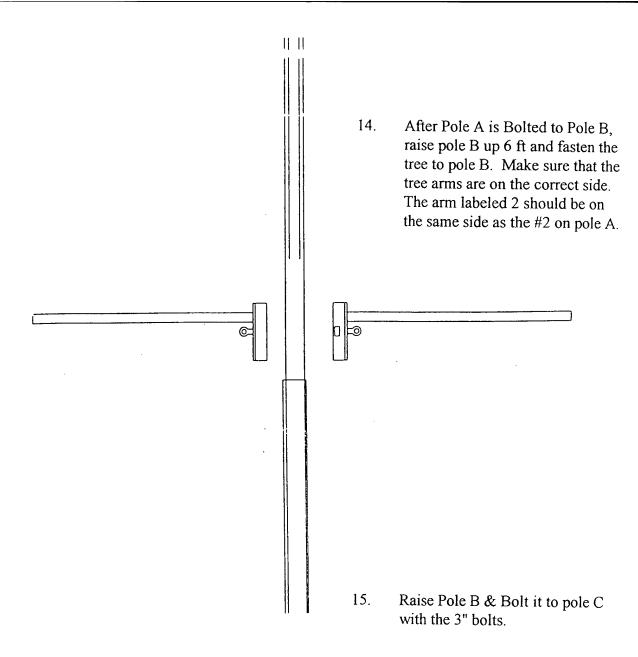
11. After the legs are bolted to the yoke, the legs should be fastened to the skids with the 6" bolts (bronze paint)

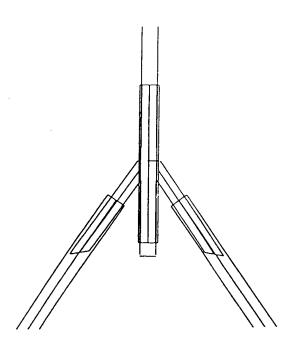


12. Attach the braces to the legs using the 4" bolts (red paint). Each side of the brace is labeled to indicate which side goes to which leg. Each of the brace backs are also labeled.

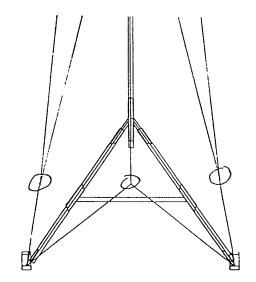


13. A ten foot ladder will be needed to raise and bolt Pole A with the purple bolts.





16. Raise pole C up and bolt into place with the 3" bolts. The bottom of Pole C should be 6" below the yoke.



17. Fasten the four turnbuckles with the same colors together. The cables may need to be adjusted to ensure the top is level. A 5/16" rachet and socket will be needed for this.